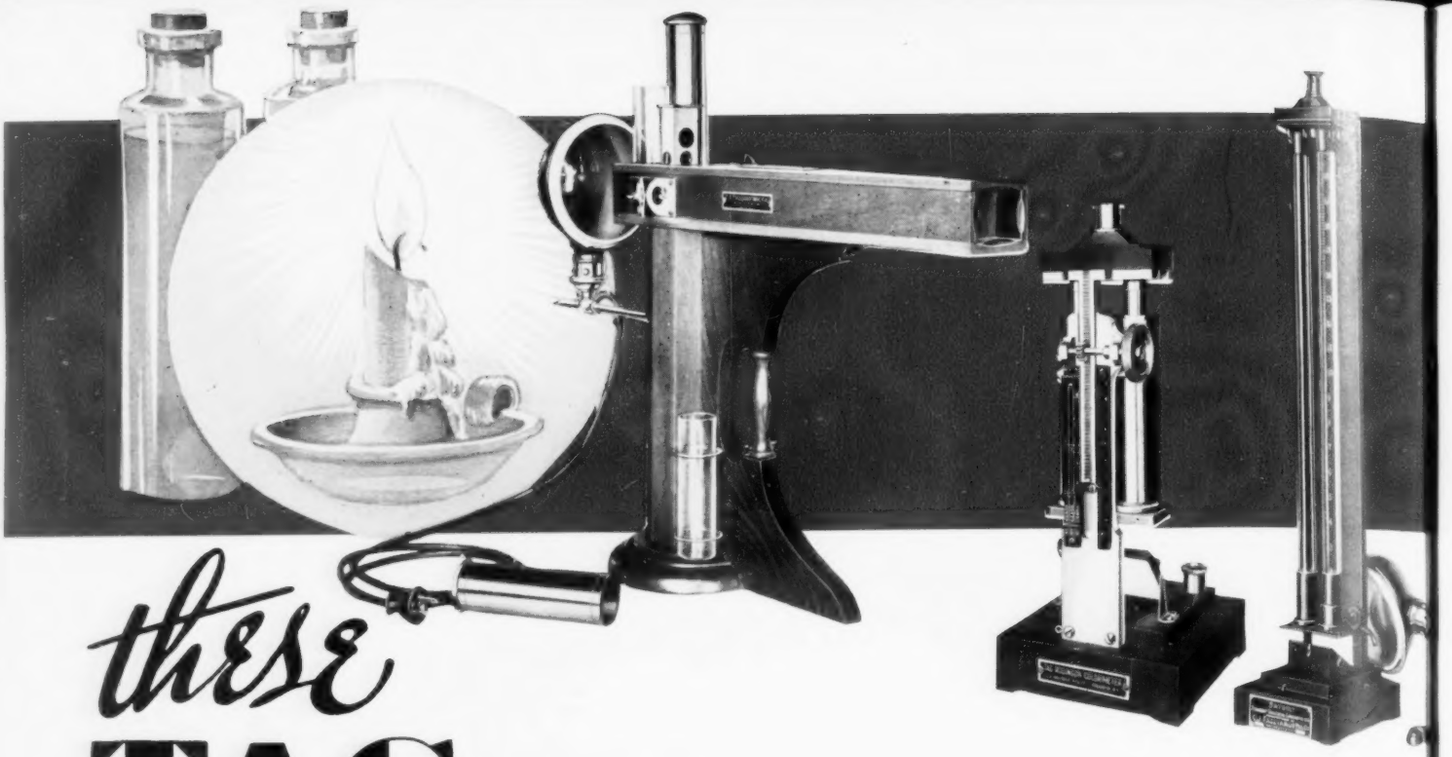
INSTRUMENTS

THE MAGAZINE OF MEASUREMENT and CONTROL

VOLUME 10

MAY
1937

NUMBER 5



these TAG COLOR INSTRUMENTS

make the sample bottle test as obsolete as Candle Light for Illumination . . .

The two new TAG Catalogs shown above should be on your desk now. No. 1100-I illustrates and describes the regular line of extreme precision and standard grade TAG Thermometers and Hydrometers, and also contains useful conversion tables and instructions for using thermometers and hydrometers.

Catalog No. 699-I illustrates and describes the many TAG Oil Testing Instruments for Petroleum Products. Send for your FREE copies today.

The first oil well in America was drilled by Drake in 1859. Three years later, in 1862, TAG'S first oil tester was patented. In 1864 the U. S. Petroleum Association adopted and recommended the use of the Arnaboldi (later known as TAG) "coal oil" Hydrometer. With that sort of tradition, it is not to be wondered that the TAGliabue organization has played an important role in the development of practically every oil testing instrument of consequence and has been responsible for the introduction of many new pieces of equipment which are now indispensable to the efficient and successful operation of the laboratories of the oil industry.

TAG A.S.T.M. UNION COLORIMETER

Numbered among the many notable TAG Oil Testing Instruments is the A.S.T.M. Union Colorimeter. It is manufactured by this Company as exclusive licensee under agreement with A.S.T.M. It operates on the principle of matching a fixed sample of oil with variable color standards. Comes equipped with 12 color standards, standard glass jars and the new TAG Daylight Lamp. For color determinations of lubricating oils and petrolatum it is universally accepted. Your laboratory is ill-equipped without this standard device.

TAG ROBINSON COLORIMETER

An exclusive TAG product, manufactured in accordance with the specifications of the late C. I. Robinson. This instrument is distinguished from the TAG Union Colorimeter in that it operates on the principle of matching a variable depth of lubricating oil with a fixed color standard. Ideal for plant control and for accurate differentiations of color shades.

TAG A.S.T.M. SAYBOLT STANDARD UNIVERSAL CHROMOMETER

Closely associated with TAG has been the name Saybolt. TAGliabue was originally appointed the sole selling agent for the Saybolt line of oil testing instruments. Later this Company took over the exclusive manufacturing rights for all the instruments developed by George M. Saybolt. Numbered among this group is the Chromometer illustrated above. It operates on the principle of matching a variable depth of oil with a fixed color standard. It is indicated for accurate service in determining color shades of kerosine and gasoline.

TAG MacBETH A.S.T.M. DAYLIGHT LAMP

Ask us about this lamp for use with each of the TAG Oil Testing Instruments described here. It provides a uniform source of daylight illumination.

C. J. TAGLIABUE MFG. CO.

Park & Nostrand Ave's., Brooklyn, N. Y.

TAGLIABUE BROOKLYN N.Y.

Round out your processing control

WITH TAYLOR FLOW AND LIQUID LEVEL INSTRUMENTS...

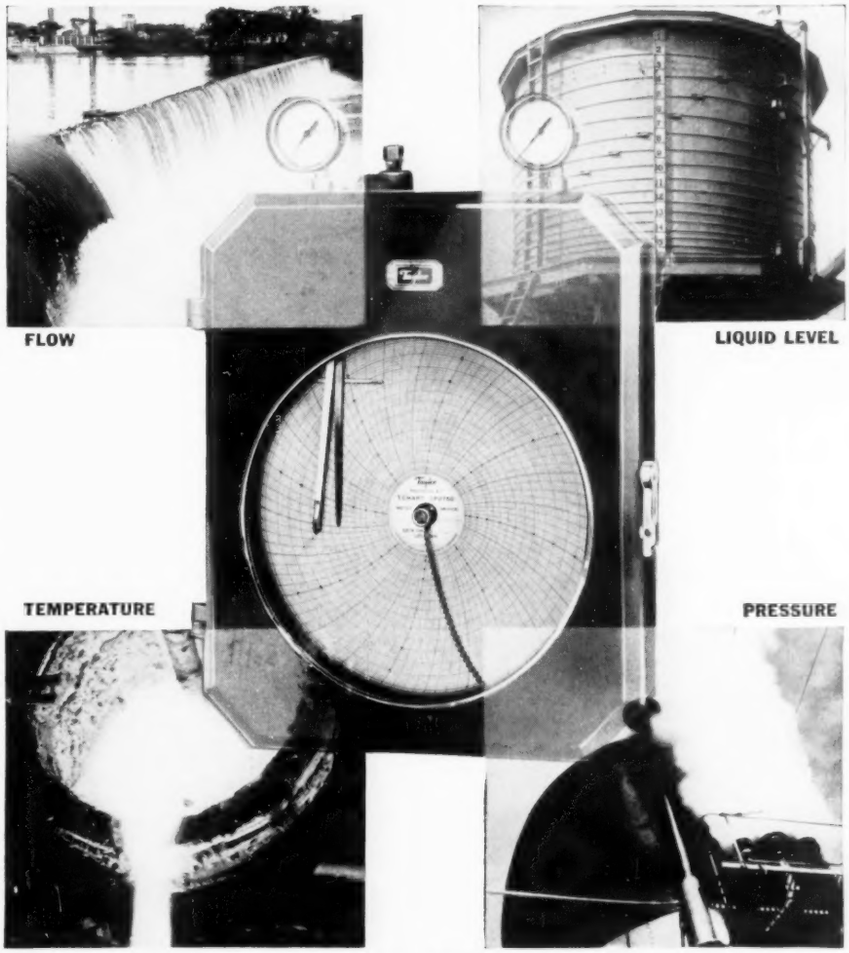
HERE is a reminder to those who say, "Flow Meters? Why, I never thought of Taylor in connection with them."

But Taylor is no new entrant into the rate of flow and liquid level fields. Its modern "Fulscope" Controllers meet practically any industrial requirements today and can be readily adapted to processing needs of tomorrow. Taylor Engineers offer you "Fulscope" Flow and Liquid Level Controllers with as great an accuracy, durability and efficiency as the Taylor "Fulscope" Temperature and Pressure Controllers so widely used throughout the industry.

AND—this is most important. In all these controllers of the "Fulscope" type the control mechanism, means of adjustment and performance characteristics are identical. The only difference is in means of actuation. So that today you can standardize on one type of controller for all phases of a continuous process—temperature, pressure, flow and liquid level.

A 100% Taylor installation is therefore possible with these important advantages: a unified system of control, undivided responsibility, quick and thorough personnel training, interchangeability of parts, lower maintenance costs and more efficient operation. This is why Taylor Control means more than the purchase of individual instruments. It is the reason why plants with Taylor Temperature and Pressure Control should see just what Taylor Flow and Liquid Level Control can accomplish. It reminds plants that have no Taylor Control at all: "Look into the unified, coordinated Process Control that Taylor Engineers can bring you."

As the first step, consult a Taylor Representative or write for the special Taylor Catalog 70J on Rate of Flow and Liquid Level Instruments. For quick action address Taylor Instrument Companies, Rochester, N. Y. Plant also in Toronto, Canada. Manufacturers in Great Britain—Short & Mason, Ltd., London, England.



FOR FLOW, LIQUID LEVEL, TEMPERATURE AND PRESSURE there are Taylor "Fulscope" Controllers with identical control mechanism, means of adjustment and performance characteristics. Used together, they give a perfectly coordinated and balanced system of process control.

Taylor

Indicating Recording Controlling

TEMPERATURE, PRESSURE *and* **FLOW INSTRUMENTS**

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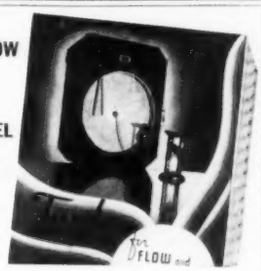

Send for full information on the modern line of Taylor Flow and Liquid Level Instruments. See how they can help to modernize your system of continuous process control to the *n*th degree. Especially when hooked in with Taylor Temperature and Pressure Control.

Write for Taylor Catalog 70J to the Taylor offices in Rochester or Toronto.

INSTRUMENTS The Magazine of MEASUREMENT and CONTROL

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Published Monthly on the 15th by
The Instruments Publishing Company
1117 Wolfendale Street Pittsburgh, Pa.

Branch offices
Boston: James Condon, 6 Marlboro St.
New York: Edwin F. Ripley, 118 E. 28th St.
Chicago: R. Farnham, 201 Wells St.

Annual Subscription: U. S. $2.00. All other countries $3.00 *payable in advance* (remit by New York draft). Copyright 1937 by The Instruments Publishing Company. Entered as second-class matter January 25, 1932, at the post office at Pittsburgh, Pa., under the Act of March 3, 1879.

INSTRUMENTS The Magazine of MEASUREMENT and CONTROL

M. F. BEHAR
EDITOR

IN THIS ISSUE

An astronomer by profession, but frequently consulted by industry—such is the author of this month's first article. We've heard, moreover, that every top-notch spectroscopic analyst around Pittsburgh has learned some theory and much "practical dope" from Dr. Keivin Burns.

P.S.—The Kevin Burns mentioned in the "Acknowledgements" paragraph is the son of the author.

P.P.S.—The names Keivin and Kevin are *not* mis-spelled.

Dr. S. R. Williams having laid the groundwork in his first four articles on hardness, he begins this month a critical survey of actual methods.

Ralph Batcher, having described many industrial applications of cathode-ray tubes, now deals with their applications to the study of the human machine.

This month's crop of new instruments includes, as usual, two or three which represent the embodiment of new *methods*. If it were not for an editorial policy based on service to instrument *users*, we'd often be tempted to run full-length feature articles on such really new devices, written by engineers in the employ of the commercial producers. As a matter of fact, we did it for Preston Bassett ("The Gyropilot") and we're thinking of giving a couple of pages to a development engineer who conceived a radically new *form* of instrument soon to be placed on the market. What do you think?

THE FRONT COVER

"Army-N.Y.U." ....."0.000001-0.000002" Intercollegiate game, and score?

No: Joint laboratory, and precision attainable in linear measurements.

At the center of the photo stands Professor De Zafra, the team Cap—beg pardon, the Major in charge. He tells you all about it on page 135. The "flaming bomb" flag is that of the New York Ordnance District, U. S. Army.

DO IT AUTOMATICALLY!

INDUSTRY faces a cruel dilemma in these days of titanic struggle between two groups of extremists who differ in their "ideologies" but agree in their ulterior purposes—to wield power without shouldering responsibility and to enjoy luxury without serving society. Ruthlessly robbed by demagogues to support dole-made unemployables and to make more unemployables, maliciously milked by pyramiders to support jugglery-made wastrels, Industry appears to face the alternative of raising its prices (and going broke by losing its markets) or drastically cutting prices to expand its markets. To cut prices without going broke, it must reduce the labor-content of every unit of sale (goods, power, transportation, etc.) through greater use of automatic devices. But this reduction of human drudgery through Instrumentation is precisely what is opposed with the cry of "technological unemployment!" by haters of "private" industry.

What the meddlers can't see is that to halt industry is to obstruct the flow of life-blood in the body politic. For Industry in its broad sense embraces not only what is implied by the shopworn expression "capital-and-labor" but all contributory services such as discovery, invention, research, transportation, communications, education—even national defense and hygienic measures and spiritual guidance—all material facilities and human activities that keep the nation healthy by continually accelerating the circulation of its life-blood.

The vascular system on whose functioning our national health depends is (to use another shopworn expression) "production - distribution - consumption." The *health* of the body politic is (to use a brand-new expression) the *second derivative* of the circulation of this blood: not the yearly total of goods and services, not even the per-capita yearly total, but the *rate-of-increase* of the per-capita rate-of-flow. This being a new theory, its basis may be given:

A boy of ten weighs twenty times as much as he did as a baby. Throughout these years his health depended on his heart pumping more and more blood into his ever-increasing mileage of arteries and veins. At birth, all the blood did was to keep up the spark of a vegetable-like existence; at ten the blood makes the boy live actively between meals.

So it is with any society as it progresses. In its infancy, its production-distribution-consumption system is so undeveloped that the society merely vegetates: everyone is poor though all adults toil. In its adolescence (the "factory" age) the system affords enough leisure for the rise of a civilization but the body politic usually suffers growing pains due to unbalanced development—the drag of maladjusted cells and the occasional ravages of malignant parasitic cells.

The manufacturing industries and utilities are the heart of the body politic. They pump the red blood—the *real* wealth. To create more and more real wealth and per-capita leisure is their mission, gradually being accomplished through Instrumentation.

Fifty years from now, people will pity us for wasting so much toil on so many repetitive operations that can be done automatically with instruments available today.

TUCKER . . . and . . . a new model . . . and . . . CUMMINGS . . . and. . . *Instruments*

INSTRUMENTS' READERS AT WORK

No. 24—STANLEY ROBINSON CUMMINGS, Director
No. 25—WILMER HARLAND TUCKER, Assistant Director
Laboratories of **The Hoover Company,** North Canton, Ohio

By M. F. BEHAR

IN this department last month we related how our readers at the Good Housekeeping Institute check up on the tests made by the manufacturers of household devices —including vacuum cleaners. It is fitting to follow it up this month with readers in this industry.

That the Hoover Company is a wonderful place in which to work is one's first impression, and we are endeavoring to convey it to you *via* a picture of the entrance to the four-story, 70 × 160 ft. Engineering Building. The Engineering Department has about 135 members and represents the allotment by the Hoover management of several million dollars during the past fifteen years. Charter Subscriber Cummings heads the Engineering Laboratories which have a personnel of about 45 and are organized into eight individual research sections:

1. Electrical Research Laboratory
2. Mechanical Research Laboratory (Includes separate Rubber, Paper and Textile Research Laboratory)
3. Acoustical Research Laboratory
4. Cleaner Research Laboratory
5. Chemical and Metallurgical Research Laboratory
6. Parts Testing Laboratory
7. Refrigeration Laboratory
8. Home Economics

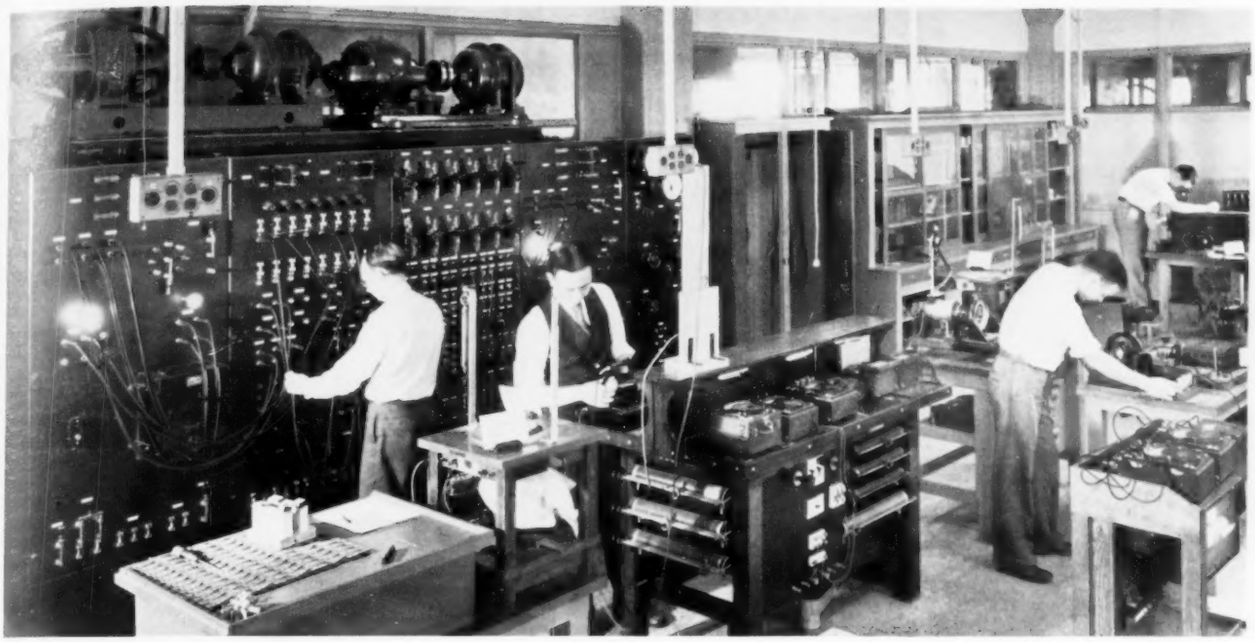
Born in 1897 in Quincy, Mass., Cummings received B.S. degrees from Harvard and M.I.T., and the M.S. from M.I.T. Following graduation he taught engineering at M.I.T., Oregon State and LaFayette. He joined the Hoover Engineering Laboratories in 1923. Since then has held positions of Laboratory Engineer, Mechanical Laboratory Section Head, Mechanical Research Division Head, and in 1933 he became Director of all the laboratories.

Tucker was born in 1896 in Colorado Springs, Colo. He attended Colorado College, completed his engineering education here in Pittsburgh (B.S., Carnegie Tech, 1923) then joined the Hoover Engineering Laboratories, where he has served as Laboratory Engineer, Electrical Laboratory Section Head, Electrical Research Division Head and, since 1933, Assistant Director.

Cummings and his staff all believe in substituting exact instrumental measurements for human observations. Supported by the company management, they are always installing the most up-to-date instruments. In fact, when they cannot find the exact type for a special purpose, they promptly have it made.

Enthusiasm for Instrumentation pervades the entire Hoover organization. The Production Department employs a large number of measuring and controlling instruments, of which 324, recently listed, initially cost $41,000. "The company looks upon instruments as good investments," said Cummings. "Its monetary allotments show its attitude toward research and Instrumentation as necessary and valuable means of keeping its product up-to-date and the leader in the industry."

Cummings concluded that "the entire Engineering Department Staff" benefits from *Instruments* which "serves a most important and valuable purpose."



Portion of electrical research laboratory

INSTRUMENTS IN LABORATORIES OF THE HOOVER COMPANY

(Estimated initial cost $213,000)

Not counting numerous special instruments and apparatus designed and built by The Hoover Company

Extensometers & Micrometers	29	Eddy Current Brakes & Loading Devices	18	Dynamic Balancing Machines	3
Chemical Balances	6	Standard Round Edge Orifices	24	Zeiss, Palmer & other Dust Counters	4
Other Misc. Weighing Devices	36	Air and Gas Meters	16	Humidifiers & Humidity Chambers	4
Electric Timers, Stop-watches & Timing Devices	64	Cathode-Ray oscillograph	1	Integrating Photometer	1
General Radio Strobotacs	4	Dudell Oscillograph	1	Automatic Polishing Machine (Metallurg.)	2
Ashdown Rotoscopes	2	General Electric Noise Meter	1	Orsat Gas Analyzer	1
Hasler, Foxboro, Frahm & other Tachometers	48	General Electric Noise Analyzer	1	Micro-photographic Equipment	1
Mercury and Aneroid Barometers	5	University of Michigan Noise Meter	1	Littrow Spectrograph	1
Pressure Gages, Vacuum Gages, etc.	121	University of Michigan Noise Analyzer	1	Miscellaneous Chemical Instruments	61
Double-pen, 1- & 7-Day Recording Thermometers	18	Microscopes	5	Ammeters & Milliammeters (A-c. & D-c.)	26
L & N 12-point Recording Potentiometer	1	Color Analyzer (Keuffel & Esser)	1	Voltmeters (A-c. & D-c.)	41
L & N Indicating Potentiometer	1	Scott Textile Testing Machine	1	Wattmeters (A-c. & D-c.)	27
Temperature Controllers & Regulators	16	Scott Rubber Testing Machine	1	Watthour Meters (A-c. & D-c.)	12
Sargent Gas Calorimeter	2	Amsler Testing Machine (20,000 lbs.)	1	Frequency Meters	2
Veeder & other Counting Devices	64	Misc. Rubber, Paper & Textile Testers	24	Bridges	8
Fractional H-p. Electric Dynamometers	18	Cenco High-vacuum Pump	2	Rheostats & Resistances	125
		Schaeffer & Budenberg Gage Tester	1	Shunts, Multipliers & Instrument Transformers	21
		Metallurgical Furnaces	6	High-voltage Transformer (30,000 V.)	1
		Electric Conditioning Ovens	9		

Portion of mechanical research laboratory

"MEGGER"
CAPACITANCE METER

Measures Electrostatic Capacity *Anywhere*

A new instrument —self - contained, with hand-generator source of test current . . . always ready for use, **anywhere.** Reads directly (like a voltmeter), compensates automatically for parallel (in-phase) resistance leakage.

Designed primarily for locating open-circuit faults in power cables, this new instrument is finding a variety of miscellaneous uses in shop, laboratory and field for capacitance measurements of cables, condensers and machines. As simple to use and as rugged as a "Megger" Insulation Tester. Ranges up to 10 microfarads, reading as low as .01 microfarad.

A shop type instrument, without automatic compensation, reads to as low as .00002 microfarad on a scale 12 inches long and using 60 cycles supply.

Write for Bulletin 1405-I.

JAMES G. BIDDLE CO.
ELECTRICAL AND SCIENTIFIC INSTRUMENTS
1211-13 ARCH ST. PHILADELPHIA, PA.

The Burling
HEAT CONTROL

For Industrial Processes

TANKS — PRESSURE VESSELS — DRYERS

50°-1400° F.

A rugged and accurate instrument that is easily installed in ovens or tanks with suitable fittings. Tubes of non-corrosive alloys. Snap action switches rated at 10 amperes, ample for auxiliary equipment.

Send for descriptive folders.

Burling Instrument Company
239-243 Springfield Ave. Newark, N. J.

NEW INSTRUMENTS

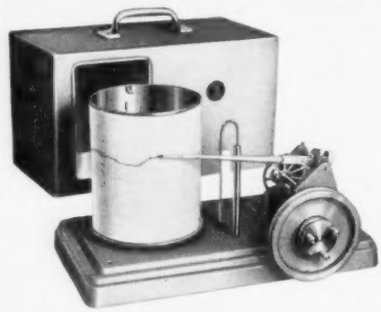
In this department we strive to report each month ALL the new devices for measurement, inspection, testing, metering and automatic control—in the form of concise technical descriptions.

When writing to manufacturers directly, please mention this department as your source of information.

Or write to Information Section, Instruments Publishing Company.

Water Level Recorders

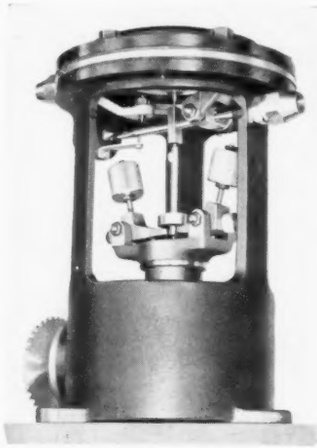
Two portable drum-chart float-operated water-level recorders are announced, alike in all respects except for the choice of chart coördinates and, therefore, of pen-actuating mechanism. "Model FW-1" (illustrated) represents a solution of the uniform-scale problem involving minimal friction: although pen-arm swivels about a fixed point, actuating cam is so shaped that vertical pen movement—whether at middle or edge of chart—is exactly proportional to water level, permitting integration of record with an ordinary planimeter. Frictional torque at float wheel is <0.25 in.-oz. and mechanism is adjusted to a tolerance of ± 0.005 ft. water level. "Model FW-2" traces its records on rectangular-coördinate charts with uniform water-level scale. These records are of ideal form



for mathematical purposes (rates of rise and form corresponding to slope, and other obvious advantages) but the pantograph mechanism makes this instrument somewhat less accurate than "Model FW-1." Both models have a temperature-compensated clock movement mounted on light aluminum base. Cover is provided with observation window and automatic safety latch and is dust- and moisture-proof when closed. Overall dimensions $6'' \times 8'' \times 12''$; weight $10\frac{1}{2}$ lbs. Float wheel is not only outside the recorder case but clears the plane of the base. Stage ratio is 5:12 (5" chart scale represents 12" of water movement) but the same heart-shaped cam which assures linearly-proportional pen-travel also causes the pen-arm to reverse its direction when it reaches top or bottom of chart, so that an unlimited range of stage is provided in 1-ft. increments by multiple traverses of the 5" chart. Eight time scales are available by change-gear combinations whereby drum period may be 6, 12, 24, 48, 96, 114 or 192 hours. All graphs read from left to right. "Moisture-resistant" charts are 14.4" long.—*Julien P. Friez & Sons, Inc., Baltimore St. & Central Ave., Baltimore, Md.*

Oil Meter & Control Device

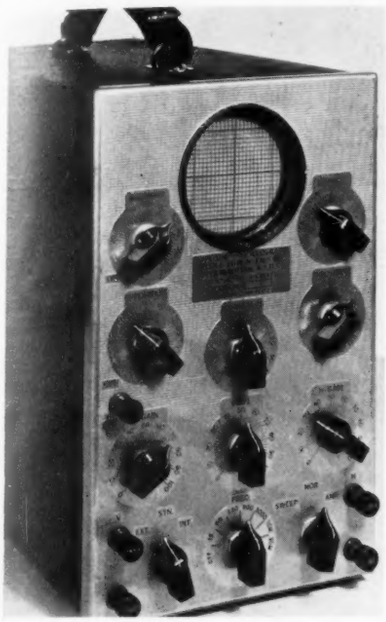
A new development for oil flow measurement, the "Askania Oil Transometer," is usable also for automatic-control purposes. Manufacturer claims that by reason of the inherent characteristics due to its design, the Transometer eliminates all errors in oil flow measurement due to changes in viscosity, temperature and specific gravity. Illustration shows device with the protecting cover removed.



The sprocket shown is driven by a chain from a positive-displacement meter. As the sprocket speed increases or decreases, with varying oil flow, the fly-ball governor rises or falls in proportion to variation in oil flow. Vertical force of fly-ball governor is transmitted to the Askania jet pipe into which air is introduced through the right-hand inlet. Air leaving the jet pipe enters a receiving nozzle connected to the top of the diaphragm. As air pressure on diaphragm depends upon position of jet pipe, the more the jet pipe registers with the receiving nozzle, the greater will be the air pressure on the diaphragm; and jet pipe position will always be such that air pressure on diaphragm balances governor force. Air pressure being in direct proportion to centrifugal force, it therefore is a square function of the oil flow through the meter. Slight pressure changes of air entering jet pipe do not affect accuracy of instrument, it is said, since jet pipe always and automatically finds a position in which air pressure on diaphragm balances the upper force of the governor. Air pressure thus created is an accurate measure of the air flow and may be used with maker's control equipment as a metering impulse in connection with any oil flow problem.—*Askania Regulator Co., 1605 So. Michigan Ave., Chicago, Ill.*

Three-inch Oscillograph

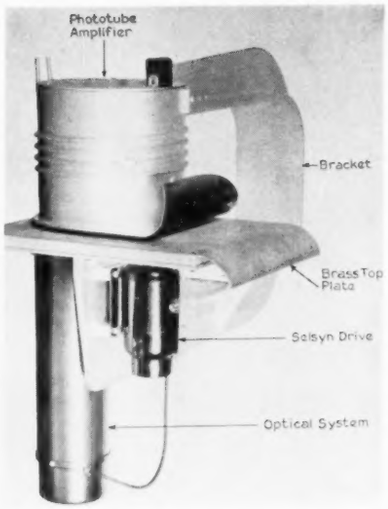
This new three-inch cathode-ray tube service Oscillograph, "Type 164," has been developed for service engineers, to be used in conjunction with any standard frequency modulator and oscillator or with any of the new designs of frequency-modulated oscillators. In addition, it is said that it will "serve the many purposes of a really efficient port-



able oscillograph as well." It employs a Du Mont Type 34-XH 3" tube; has separately controlled horizontal and vertical high-gain amplifiers, flat from 30 to 30,000 cycles per second; internal or external positive synchronization; high- and low-voltage power supplies, assuring a brilliant pattern and no interaction of controls. Provisions for applying signals direct to the deflection plates have been made at the rear of the unit. All controls (including horizontal and vertical positioning controls) are on front panel. Unit has an amplified sweep with a frequency range which allows observation of a single wave from 15 to 30,000 cycles per second.—*Allen B. Du Mont Laboratories, Inc. Upper Montclair, N. J.*

Photoelectric Control Removes Skew from Cotton Cloth

To aid in producing uniformly straight cloth at higher speeds, this new photoelectric control operates a cloth-straightening device which removes skew from cotton cloth during the tentering or stretching process; also reduces operator fatigue. Two photo-tubes are mounted over the cloth, one on each side of the tentering machine, and light sources are located beneath the cloth directly under the phototubes. (Illustration shows one of these two combinations.) As the cloth progresses through the tenter, the tubes receive an equal number of light flashes between threads if the cloth is straight. If the cloth becomes skewed, however, one tube receives more frequent light flashes than the other. In consequence, the frequencies on the tubes will be unequal. By means of amplifiers and a frequency-responsive circuit, inequality of frequencies causes actuation of relays controlling, through a magnetic switch, a straightening motor which advances or retards one edge of the cloth with respect to the other, thereby removing the skew. Cloth speeds may vary from 20 to 140 yards per minute, and the weft-thread count may vary from 20 to 100 per inch in closely woven shirting.—*General Electric Co., Schenectady, N. Y.*



Metering Solution Feeder

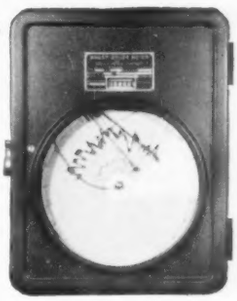
Initially brought out as a water chlorinator for paper-making processes, flour mills, swimming pools, waterworks, sewage treatment, etc., the "Rota-meter Vacuum Chlorinator" can obviously be adapted to applications involving other fluids than water and chlorine. It is available in two styles: the "de luxe" (illustrated) and the "Type R" wherein all parts are assembled on a steel frame

for maximum accessibility. Its metering element is a "Rota-Meter" (see *Instruments*, Dec. 1933, pages 222-225; April 1935, page 107) in a choice of nine sizes with capacities of 0.5-5.0 to 10-100 lbs. of chlorine gas per 24 hrs. Other essential components are a chlorine gas control valve assembly, an injector-and-absorption tower assembly, a safety vent and vacuum break, and a water supply manifold.—*Everson Mfg. Co., 214 West Huron St., Chicago, Ill.*

BAILEY METERS

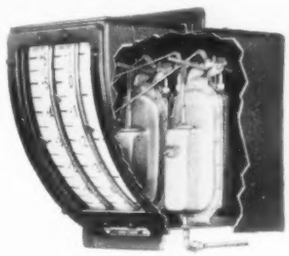
METERS and CONTROL *for Boiler Room Service . . .*

Boiler Meters Indicate, record and integrate Steam Flow from the boiler, record Air Flow supplied for combustion and record Flue Gas Temperature. The use of this meter reduces fuel cost, lessens maintenance and outage, lowers standby costs, and adds capacity.



Bailey Boiler Meter

Multi-Pointer Gages for indicating drafts, pressures, differentials are available with any number of pointers from one to twelve. They are actuated by sturdy yet sensitive diaphragm units.



Multi-Pointer Gage

Flow Meters. For indicating, recording and integrating the flow of steam, feed water, compressed air and other fluids.

Coal Meter

Granular Material Meters For accurately measuring the flow of coal or other granular materials in gravity chutes from overhead bunkers. The total quantity of granular material is shown on a large illuminated counter which may be easily read at a distance of 50 feet.

Control Systems. Make possible the every-day operation of equipment for steam generation and utilization at test efficiencies. They are applied to the control of combustion, feed water, superheat, desuperheat and other factors.

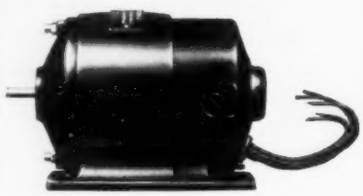
Complete Information on any of the above Bailey products will be gladly furnished upon request.

G-7

BAILEY METER COMPANY

1041 Ivanhoe Rd., Cleveland, Ohio

REMOTE INDICATION *and* CONTROL



. . . is usually a job

for AUTOSYN SELF-SYNCHRONIZING MOTORS!

TYPE 1 AUTOSYN MOTOR is a reasonably priced self-synchronizing motor with superior performance characteristics. One transmitter may operate as many as six receivers. Practically any system of remote indication or control may be solved by the selection of the proper type of Autosyn Motors.

FEATURES:

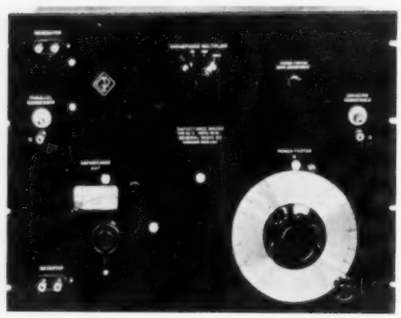
1. Conventional Motor mounting interchangeable with most standard self-synchronizing motor elements.
2. Approximate accuracy: Two degrees.
3. Maximum torque 14.8 inch ounces.
4. Safe continuous operating torque 5.6 inch ounces.
5. Brushes carry no current during synchronism.
6. Enclosed inertia dampener reduces oscillation to maximum of 3 seconds and is adjustable to suit.
7. Dimensions: 3-5/8"x3-9/16"x5-3/4".
8. Weight: 5 lbs., 12 oz.
9. Low current consumption and temperature rise characteristics.
10. Voltage range for accurate and safe operation, minus 20% to plus 10% normal rating.

Complete information on request.

BENDIX MARINE PRODUCTS CO., Inc.

(Subsidiary of Bendix Aviation Corporation)

754 Lexington Avenue
Brooklyn, N. Y.

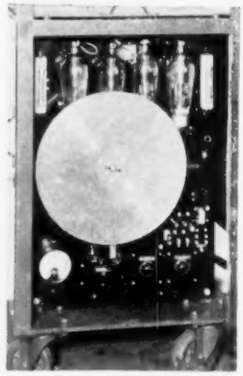


Audio-frequency Schering Bridge

"Type 716-A" Capacitance Bridge is an audio-frequency Schering bridge, direct-reading in capacitance up to 1 μf and power factor up to 6% (0.06 expressed as a ratio). Range thus covers most paper condensers, cables, slabs of solid dielectric, liquid in large cells, and ground capacitances of generators and transformers. Accuracy over the direct-reading range is, for capacitance, $\pm$ 2 $\mu\mu$f for the air capacitance range (100 to 1100 $\mu\mu$f), and $\pm$ 2 $\mu\mu$f multiplied by the decade multiplier setting for higher values. For power factor, accuracy is $\pm$ 0.0005 or $\pm$ 2% of dial reading. Power factor dial is calibrated in power factor at 1 kc. Other frequencies between 60 cycles and 10 kc. can be used, and power factor is obtained by multiplying dial reading by frequency in kc. For greater accuracy, substitution methods can be used. A set of capacitance standards embracing both air and mica units may then be intercompared to 0.02%. Other types of capacitance bridge circuits can be used with this instrument, as, for instance, series and parallel resistance arrangements, by adding external resistors and precision condensers. Bridge thus has a wide field of application. It is available in either relay-rack or cabinet mounting. Dimensions 19" × 14" × 9" over-all. Net weight of the relay-rack model 41 lbs., of cabinet model 52 lbs.—*General Radio Co., 30 State St., Cambridge, Mass.*

Ignitron Seam Welder

A new ignitron seam welder control utilizing ignitron tubes times the power impulses in terms of a definite number



of power cycles to wheel type electrode resistance welding machines. Among its features is an inductive timer, consisting of a synchronous driven disk rotating once per second and containing 120 holes, each corresponding to a half-cycle of welding current. Also, the use of ignitron tubes permits a design utilizing no voltages higher than line voltages and eliminating the need of power contactors and transformers. Steel pins are plugged into the holes according to the timing desired. Use of this new control, it is said, greatly improves the quality of welds for even light-gage steels. It is especially suitable, however, for welding heavy-gage steels demanding heavy welding currents, and special alloys demanding accurate timing and often heavy current such as aluminum and olympic bronze.—*Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.*

Oscilloscopes Using 2" Tubes

Two new cathode-ray oscilloscopes of small size are announced, using a 2" screen tube (7" long) which, though having four times the screen area of a 1" screen tube, requires no more operating voltage than the latter. "Model 535," the larger of the two, can be used as a complete visual servicer in conjunction with a frequency modulated signal generator; employs return sweep eliminator for completely removing high frequency linear sweep return; provides selective return sweep eliminator for inclusion or rejection of power supply frequency return sweep; includes positive interlocking circuit between linear time base and incoming signal; has "Uni-control" allowing both horizontal and vertical spot centering knobs on panel from but one shaft protrusion," horizontal and vertical amplifiers; means for controlling gain in two amplifiers; linear time base (saw tooth) oscillator from 15 to over 30,000 cycles; switching systems for routing incoming signals direct to cathode-ray tube or through amplifiers, and intensity and focus controls. "Model 530" has somewhat fewer features, is said to be the smallest and lightest oscilloscope on the market having equal functions and ranges. — *Supreme Instruments Corp., Greenwood, Miss.*

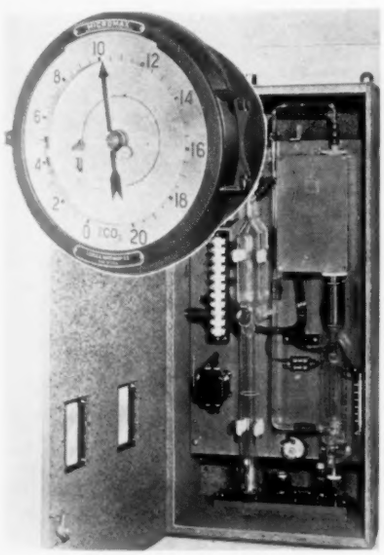
Cathode-ray Oscillograph Using 1″ or 2″ Tubes

New "Junior Oscillograph Model RFO-[illegible] is of compact design, has a built-in electronic frequency modulator, will operate with any good radio-frequency

oscillator, operates on the same principle as oscillographs using 3″ tubes. A special feature is that the tube screen is mounted in a recess behind the panel, thus being shielded from interference of light. Control has been simplified to enable inexperienced operator to put the circuit to work with a minimum of study and experimentation. The sweep circuit oscillator in this instrument is claimed to have a wider range and to be more flexible than the sweep circuit found in similar oscillographs. Range is variable from 1 to over 150,000 cycles/sec. Case is 11″ wide × 9″ high × 7″ deep.—*The Hickok Electrical Instrument Co., 10514 Dupont Ave., Cleveland, Ohio.*

CO_2 Recording Equipments Using Saturation Method

After confirming reports of greater speed of response, higher accuracy and lower maintenance costs, received from a number of plants where installations were made, makers now announce that an entirely new type of CO_2 equipment is added to their line. No change is made in recording instruments proper (the "Micromax" line) but the gas-analysis cell assembly employs a new principle. Instead of drying a continuous flue-gas sample, the new cell assembly saturates it with water vapor, doing away with difficulties attending the care of dry-gas equipment. Its construction eliminates corrosion, thereby preventing drift in cell calibration. It minimizes time-lag in conditioning gas for measurement and does away with use of chemicals. Alternating current is used throughout. A single conection to a 110-volt line supplies both recorder motor and measuring circuit. There is no battery, no charger, no rectifier and no occasion for current adjustment. Continuous measurement of the CO_2 in the saturated continuous sample is made by the thermal-conductivity method, the electrical resistance of a resistor in the sample being compared with that of an identical resistor in the reference standard-gas-filled cell—both at the same temperature. A null-balance circuit is used, and the unbalance e.m.f., representing the CO_2 percent, is recorded on the chart. The recorder having a potentiometer circuit, lead length and lead temperature gradients have negligible effects on accuracy.—*Leeds & Northrup Co., 4955 Stenton Ave., Philadelphia, Pa.*



Industrial Pyrometer Radiation Receivers

Three new forms of radiation-receiving tubes, of rugged construction for industrial plant service, yet employing thermally-responsive elements of laboratory accuracy, are announced for use as primary elements in connection with maker's "Micromax" line of potentiometers. In all forms, the radiation receiver proper, known as "Rayotube," is of new design but utilizes same general principle as in older L&N receiving tubes: concentration of radiant flux on junction of a thermocouple. Fig. 1 shows "No. 8816 Wide Angle Rayotube" assembly, designed for sighting directly on the work in a furnace. Fig. 2 shows "No. 8818 Narrow Angle Rayotube" assembly with silicon carbide target tube (available in various diameters and lengths) projecting inside furnace or kiln. The third form (not illustrated) has its Rayotube mounted inside an aluminum head with air-cooling fins.—*Leeds & Northrup Co., 4955 Stenton Ave., Philadelphia, Pa.*

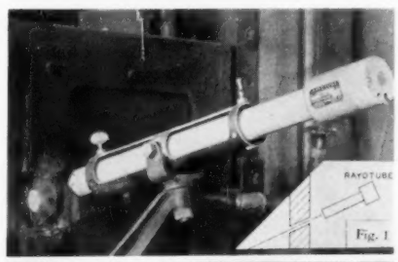


Fig. 1

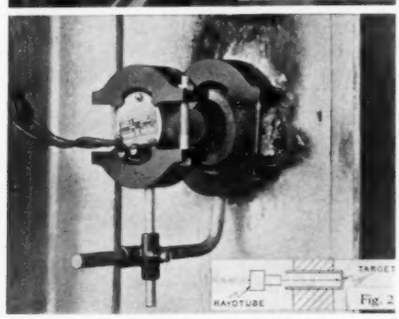
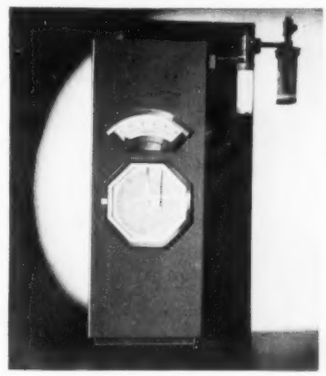


Fig. 2



INCREASE
BOILER EFFICIENCIES
with a
REPUBLIC CO_2 METER

The latest developments in the measurement of CO_2 are incorporated in this new design of Republic CO_2 Meter.

The redesigned Republic CO_2 Meter incorporates the following important features:

- The CO_2 is measured by the Orsat method.
- Meter readings are free from the effects of temperature variations.
- The meter has a gas suction powerful enough to draw 14 inches of mercury. This eliminates the possibility of stoppage in the sampling line.
- The Republic Meter is driven by a fractional horse power motor and no water is required for its operation.
- A filter in the gas line removes all SO_2 before it reaches the meter.
- The large caustic tank holds enough potash to last from 4 to 6 months.
- The simplicity of the meter and its rugged construction eliminates the necessity for frequent servicing and adjusting.
- Hundreds of companies have used the Republic CO_2 Meter for many years and recognize it as standard for the mechanical measurement of CO_2.

Data Book 403, just published, gives complete description.

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HELLIGE
GLASS ELECTRODE
pH-METER

READING DIRECT FROM 0 TO 14 pH

For All Types of Electrode Systems

The new Hellige glass electrode pH-Meter measures hydrogen ion concentrations and reads direct in pH units with all types of electrode systems, over the complete range of 0 to 14. The sensitivity is 0.02 pH and the working accuracy is 0.05 pH. Rugged — Portable — Applicable for titrations and as a separate null indicator.

VACUUM-TUBE GALVANOMETER

This instrument is a general purpose null indicator of universal adaptability for precise measurements of oxidation-reduction potentials, streaming potentials, insulation resistance, and various types of bridge measurements.

Suitable for measuring systems of high resistance (10^{10} ohms), and those easily polarized, with the same high sensitivity (0.1 millivolt) and the same simple technique as that of ordinary systems.

HELLIGE
INCORPORATED
3702 NORTHERN BLVD. LONG ISLAND CITY, N.Y.

Electrically-operated Flowmeter

A new electric telemetering system known as the "Synchro-Meter" is announced for flow-metering applications with a primary measuring assembly responding to differential pressure. It can of course be used for some other purposes with little or no modification. Its essentials are a transmitting unit, Fig. 1,

Fig. 1

operated by a Ledoux bell flow-measuring mechanism (of type used in maker's standard mechanically-operated fluid meters); and a receiver consisting of the desired indicating, recording and integrating instruments. Among advantages claimed for new system are that the transmitter places only a negligible retarding force on the measuring device; that the torque developed to operate the receiving element is ample but does not send any reaction back to the transmitter; that no adjustments being necessary at the transmitter, it may be located in a relatively inaccessible place; and that several receivers may be operated from one transmitter. Calibration is said to be simple and permanent: two scales, one on the transmitter and the other on the receiver, make it possible to test the transmitting system without calibrating the flow-measuring element and conversely, to calibrate the flow measuring element without using the electrical system. In the former test, readings at the transmitter and at the receiver are compared, while in the latter reading are taken directly at the transmitter by means of the indicating pointer provided for that purpose.

Three wires are required. With No. 12 wire, transmitter may be located approx. 1 mile from receiver. With larger wire, a greater distance is allowable provided loop resistance <20 ohms. System operation is a.c., 95 to 125 volts, 25, 50 or 60 cycles.

Fig. 2 is a schematic wiring diagram. Transmitter consists essentially of the mechanically-operated measuring device ("meter"); two contact arms swinging about points M and C; and a constant-speed cam arranged to swing lower contact arm in a continuous reciprocating cycle. Upper arm is positioned by the flow-measuring device through mechanical stop HT. The receiver (indicating, recording and/or integrating) operates in a similar manner except that the upper contact arm is positioned by the reversing induction motor. The lower arms in both transmitter and receiver are caused to rise and fall by means of identical cams driven by synchronous clock motors.

An induction motor provided with shading coils A and B is the means employed to position the receiver. Short-circuiting one coil produces rotation in one direction, and *vice versa*. If both coils are short-circuited or open-circuited

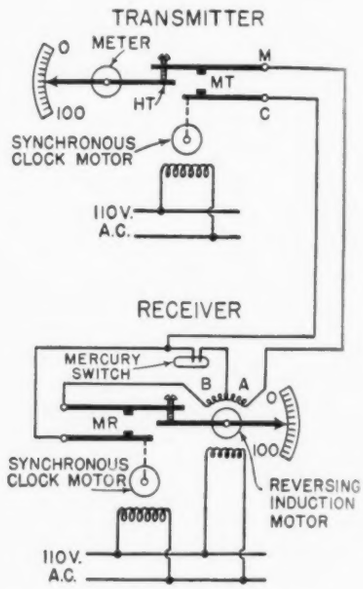

Fig. 2

simultaneously, no rotation results. Contacts MT in transmitter are connected to short-circuit shading coil A when mercury switch is closed, whereas contacts MR in receiver are connected to short-circuit coil B. If contacts MT and MR close simultaneously, reversing motor will not rotate—hence transmitter and receiver stay in correct relation with each other.

If flow-rate decreases, contacts MT will be closer together than contacts MR and will close first, short-circuiting coil A, causing counter-clockwise rotation of the reversing induction motor until receiver reads same as transmitter. Likewise, if flow-rate increases, contact MT will be farther apart and contacts MR will close first, short-circuiting coil B, causing clockwise rotation of receiver motor.

The mercury switch, shown in the common line and installed in the receiver, is closed during the positioning cycle, but is open during the rest of the cycle. Opening of mercury switch takes place before contacts MT and MR open on the down strokes of the roller arms. In other words, contacts MT and MR close the shading coil circuits, but never open them. This keeps the contacts in good condition. In case of power failure, provision is made for automatically reëstablishing the proper phase relation between the transmitter cam and the receiver cam so that the system remains accurate.—*Bailey Meter Co., 1041 Ivanhoe Road, Cleveland, Ohio.*

Fig. 1

Photoelectric Reflectometer

For determinations of light-reflecting efficiencies of flat surfaces and light-transmission properties of transparent or translucent materials the "G-E Light Cell Reflectometer" employs two light-sensitive cells, responding to the relative amounts of light (a) received by material under consideration and (b) redirected or transmitted thereby. A 10" hollow sphere is equipped with a movable tubular arm about a foot in length. Inner surface of sphere is painted flat white. The two photocells, so embedded in the "equator" as to face each other, are connected to a microammeter mounted atop the device. Held in the "hand" of the arm attachment is a small projection lamp and reflector by which a shaft of light may be directed into the sphere. The arm may be swung to such a position that the entering beam shines down through a 3" circular opening at the bottom of the globe.

To determine the reflection factor of a flat surface, Reflectometer is set on or against sample in such a way that the opening in the sphere is actually closed by the sample. Projection lamp is then turned on and a rheostat, on the arm, adjusted until pointer of microammeter rests exactly over "100" mark on scale. Light is thoroughly diffused by the mat finish of the sphere's inner surface. Operator next swings the arm into such a position that the beam of light falls at 30° from normal and directly upon sample. Reflection factor of the surface being tested is indicated on scale. Fig. 1 shows determination on a wall surface.

To measure transmission factors, Reflectometer requires another sphere of similar size (see Fig. 2) with a small opening at its top. Inside, a silvered-bowl lamp is mounted base down. To measure transmission factor of a sample, reflectometer sphere is placed upon the second sphere so that the openings coincide. Then the lamp in the lower sphere is lighted and a rheostat adjusted until microammeter on top of reflectometer sphere reads 100% of the scale. All the light that enters upper sphere is thoroughly diffused by lower sphere since the silvering on the lamp in the lower sphere prevents any direct light from reaching the opening. Cells in the upper sphere are activated by the light which comes from the lower sphere. Sample to be measured is inserted between the openings of the two spheres. All light entering upper sphere and activating the cells is transmitted through sample. Microammeter then directly indicates transmission factor of sample. — *General Electric Co., Nela Park, Cleveland, Ohio.*

Fig. 2

High-capacity Dry Cells

A line of 1 kwh. capacity primary power carbon cells is announced, supplementing maker's "Type 517 AD" dry cell. New products are of similar design but in view of their greater capacity a liquid electrolyte has been adopted. Provision is made for introduction of water at location where cells are installed. Until this water is added, electrolyte is solid, reducing weight and shipping and handling costs. Electrolyte thickens up as cells are in service, from which point forward the product is in every way a dry cell. In addition to air depolarization, new cells are said to employ an entirely new feature of regeneration, whereby cubic volume of battery for a given capacity is said to be "much less than that of any previous primary battery or dry cells made." On any work within their current ratings the cells are guaranteed. The types now being placed on the market are suited for signaling, communications, control circuits, radio tubes, instruments and applications where there are no heavy peak load requirements. Continuous discharge ratings:

"Type 618".....0.250 amp.
"Type 2618".....0.250 amp.
"Type 619".....0.500 amp.

Proper operating load for continuous work is 20% less than above. On intermittent work, continuous output rating can be doubled, but rest periods must aggregate daily the same time as the discharge periods. Within these ratings the guaranteed capacities are:

Type	*Amp.-hours*	*Watt-hours*
618 (1.4 v.)	850	1000
2618 (2.8 v.)	425	1000
619 (1.4 v.)	850	1000

New cells are said to be able to withstand low operating temperatures.—*Le Carbone Co., Boonton, N. J.*

HIGHEST
HICKOK
ACCURACY

SWITCHBOARD TYPE
INSTRUMENTS

A. C. AND D. C. ALL RANGES, ALL TYPES
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SQUARE AND ROUND CASES
4" TO 9" SIZES

A. C. AMMETERS
VOLTMETERS
WATTMETERS
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FREQUENCY METERS
In Six Different Sizes

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VERY LATEST DESIGNS

Also portable precision testing equipment; transformers, shunts, multipliers, power analyzers, etc. . . . All backed by thirty years experience in the manufacture of laboratory grade electrical instruments.

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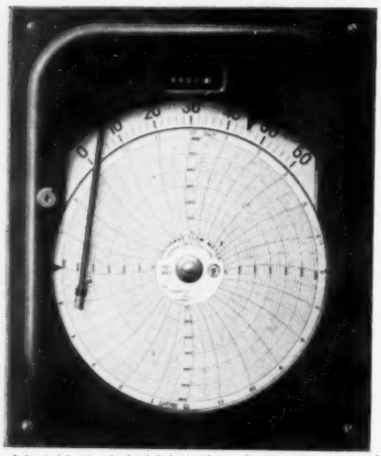
Accurate — Sensitive — Rugged



Adaptable to industrial service wherever the flow of steam, water or other liquids or gases is involved. Cochrane Flow Meters are sturdily built and extremely sensitive to variations in flow.

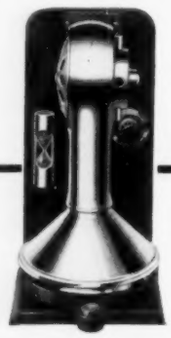
Recorders of both the Electric and the Mechanical models are guaranteed accurate within one-half of one per cent of absolute under full load.

Cochrane Electric Flow Meters operate on the super-accurate galvanometer null principle. They may be installed at any distance from the pipe line, facilitating central panel grouping.

Send for complete information

COCHRANE CORPORATION

3120 North 17th Street, Philadelphia, Pa.



MOISTURE
Content by Drying

The Moisture Teller as illustrated above will dry 50 or 100 gram test samples at the rate of one per minute. Test samples are weighed before and after drying to obtain moisture content in percentage.

Used in the following industries: Foundry — Paper — Mining — Rubber — Milling — Textile — Tobacco — Food — Brick, etc.

Rapid and accurate moisture test for either laboratory or shop moisture control.

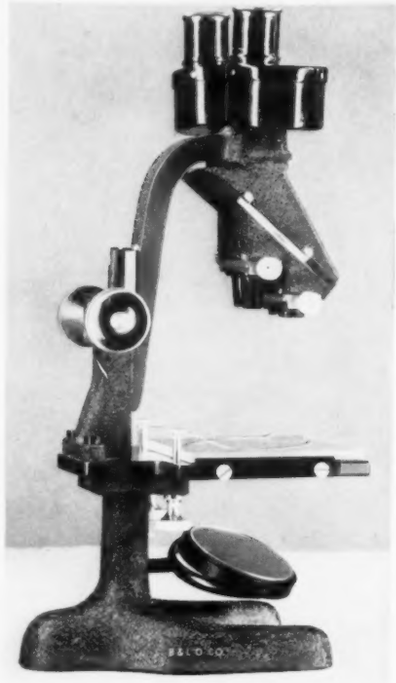
Write for Literature

Harry W. Dietert Co.

9330 Roselawn Avenue
Detroit, Michigan

Wide-field Binocular Microscopes

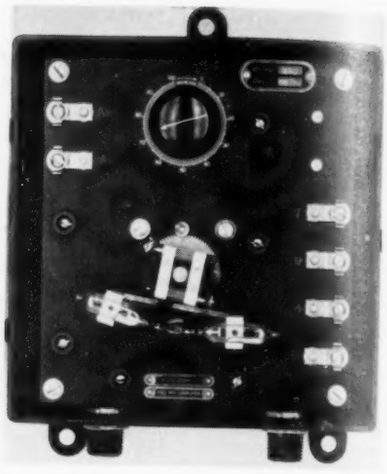
New "Model K" binocular microscope is offered to fill need in some industrial (or educational) work for a Greenough type instrument somewhat smaller and



lighter than maker's wide-field "KW" which it supplements. Body is Greenough type; stage is metal with removable glass insert and removable metal plate (white on one side, black on reverse); one plane and one concave mirror in fork mount; new dust-proof shuttle nosepiece carrying any two pairs of objectives (except 0.39× and 0.7×) in parfocal position. Fourteen combinations of paired objectives and of paired eyepieces are available with the "Model K"; five with "AK Junior"; five with "BK Junior."—*Bausch & Lomb Optical Co., 615 St. Paul St., Rochester, N. Y.*

Anti-hunting Device for Pyrometric Control

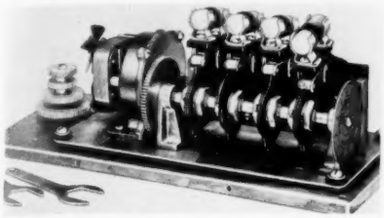
Elimination of hunting or over-control is made possible by new model of the "B-Linator," an auxiliary device which need only be cut-in between a thermocouple and a control instrument. Its particular function is to impress into the thermocouple circuit a slight additional emf. that augments the thermocouple emf. when the temperature is "low" (below the control point) and opposes it when the temperature is "high." The effect of this selective action is to cause the control instrument to anticipate the return of normality, and hence to prevent over-shooting. Thus, on a rising temperature, the heat input is decreased (by turning on a valve, switching off electric current, etc.) at a temperature slightly below the desired control temperature set on the instrument, and conversely, on a falling temperature, heat is increased when a temperature is reached that is slightly above the instrument setting. By using two simple adjustments provided for the purpose, it is said that the B-Linator can be adjusted to such close control that a separate and independent recorder, its thermocouple in or near the work, will draw practically a straight line. Installation is simple. Since the correcting or anticipating action of the B-Linator is entirely adjustable to whatever values may be required, it is applicable to 2-position control systems regardless of (1) type of thermocouple used, (2) make of control pyrometer, and (3) operating temperature. The B-Linator operates in conjunction with any of the electrically-operated valves, magnetic contactors, relays or similar regulating apparatus ordinarily used with 2-position or 3-position pyrometer control systems. In many cases where 3-position control is in use, control can be improved, it is said, by changing the system to 2-position and applying the B-Linator. The change, a simple one, is accomplished by connecting two of the three control positions together, electrically, at the control pyrometer. If a true temperature record is desired of a control operation governed by the B-Linator, the temperature should be recorded on a separate recorder. The B-Linator corrects control conditions arising from temperature lag, and it is therefore applicable not only on new control installations but also for systems already installed and in use, where the troublesome effects of lag have not yet been conquered.—*The Bristol Company, Waterbury, Conn.*



Time Cycle Controller

Installation of a recently developed timing dial on the cam shaft greatly simplifies, it is said, the timing of this time cycle controller for precision operation. It is claimed to embody a new and exclusive method of controlling electrical circuits for definite time cycling. Mechanism and construction are said to be "a departure from expensive and complicated devices previously available." Illustration of "Laboratory Model" shows the new timing dial mounted on camshaft that operates rocker arm assembly holding Staley metallic mercury switches. Cam is graduated in degrees from 0 to 360. In making a complete change of the controller timing, the first of the progressive circuits is started at 0° and timed for the on and off position of the switch. Each following circuit then is timed to its respective position

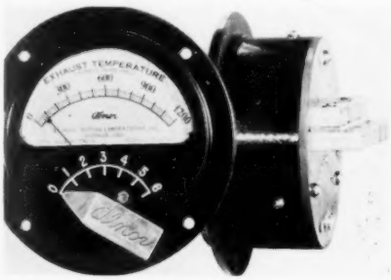
of 360°. "Standard" models are provided with camshaft speeds specified by the customer. "Laboratory" models are equipped with six change gears to give 1, 2, 3, 4, 5, 10, 15, 20 and 25 r.p.m. of camshaft. The "No. 611" laboratory



model is equipped with one-, two-, three- and four-lobe cams giving 15, 30, 45 and 60 operating cycles per minute. Speeds from one break in 3 minutes to sixty breaks per minute are available on the "611" model; from one break in 15 minutes to 25 breaks per minute on the "602" model. Unless otherwise specified, special controllers are provided in one speed only.—*Electric Switch Corp., Columbus, Indiana.*

Multi-Point Pyrometer for Diesel Engine Exhaust

New "Alnor Type 3023" Round Style Pyrometer with self-contained selector switch has been designed especially for measuring exhaust temperatures of small Diesel engines; is made for flush mounting on instrument or panel board at-



tached directly on the engine, or distantly located. Selector switch can be furnished in 2, 4, 6, 8, 10 or 12 points. Scale range 600° F., 800° F., 1000° F., 1200° or 1600° F. Extreme case diameter is 4"; depth including terminals located conveniently on back of case, $2\frac{3}{4}$". Small size and self-contained design are said to fit this pyrometer for use on instrument boards of trucks, busses, and for all small Diesel engine service.—*Illinois Testing Laboratories, Inc., 142 W. Austin St., Chicago, Ill.*

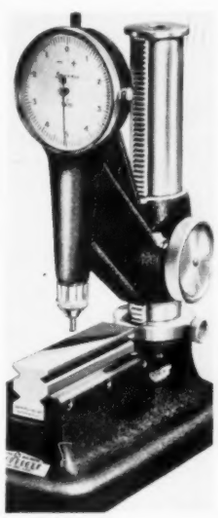
Projection Equipment for Map Making, etc.

Any photograph up to 10" square (or a 10" square portion of a larger photograph) can be projected on the drafting board of this new instrument. Beside photographs, photographic prints, drawings, sketches, charts, manuscripts, textiles or printed material may be projected, and a blast of air sent into the light chamber by a motor-driven fan keeps the object cool. The projector has adjustments so that an image of a 10" photograph can be projected on the

drafting board enlarged to 25" or reduced to 4" in order to fit the desired scale. Adjustments for position are also provided.—*Spencer Lens Co., Buffalo, N. Y.*

Comparator Gage

A simplified form of the Sheffield No. 3 Visual Gages (see *Instruments*, June 1935, page 163) is offered for the field of comparator gaging. Its gaging head, similar to that of the No. 3, utilizes the fine adjusting sleeve for rapid movement of the dial hand to the final setting. This gaging head is raised and lowered by the handwheel on the right, for adjustment to the proper height above the lower anvil, and is then locked by means of the clamping wheel on the left. The entire gaging head may be



swiveled on the column to provide gaging from surfaces other than the self-contained anvil. Standard make indicators are mounted on the gaging head. These can be secured in both the 0.001" and 0.003" range. Either indicator may be read rapidly to "tenths" by experienced operators. As illustrated, the base carries the maker's standard visual gage anvil, but special anvils can be supplied for unusual requirements. The steel column carrying the gaging head is pressed into the base at the rear. The gaging spindle or upper anvil is of the same design used in maker's visual gages.—*Sheffield Gage Corp., 1517 East 3rd St., Dayton, Ohio.*

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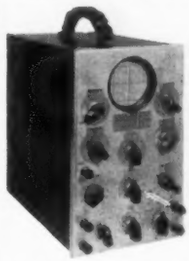

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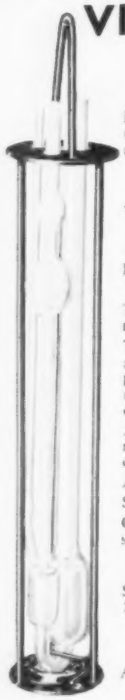
By L. Ubbelohde

U. S. Patent No. 2018305



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V—the kinematic viscosity in centistokes.

t—the efflux time in seconds.

K—the calibration factor of the instrument.

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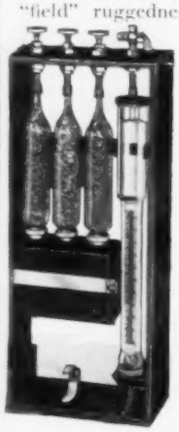

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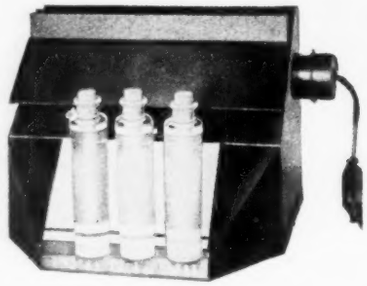
Clarity Tester

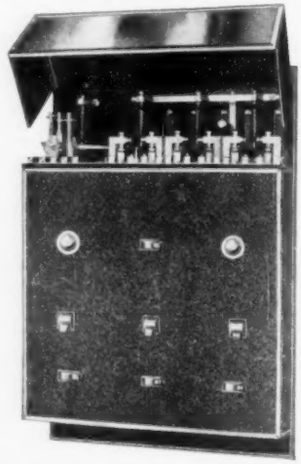
For laboratory and works control, this new device is for observing the clarity of liquids and estimating traces of suspended matter. It is claimed to show clearly differences of 1 p.p.m. (0.0001%).



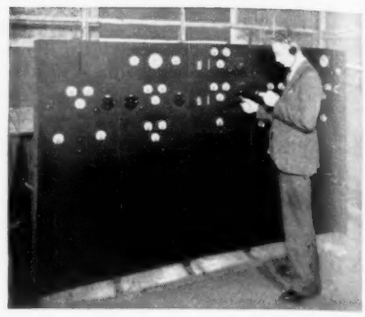
Proper illumination on sample (against a "practically invisible" black background) can be modified with respect to diffusion, color and intensity with diffusion plates and color filters according to requirements of each problem. *Operation:* (1) Place liquid, in any convenient bottle, on the observation platform. (2) Look at it. Suspended matter may be observed both nephelometrically (by reflected light) or turbidimetrically (by transmitted light).—*Laboratory Equipment Co., 146 Lafayette St., New York City.*

Voltage Regulator

New Burlington voltage regulator is of high-speed vibrating type, with alternating current only for the operation of the main a-c. element, as well as for the relays. In connection with the relays, a rectifier element is used to produce the necessary smooth voltage. New regulator is said to be quick in response to large load changes, "starting corrective action rapidly and completing it in a shorter time than any other regulator on the market." Quantitative example:



a full load change of either all-resistive or all-inductive load can be picked up with a completely restored voltage in 6-8 cycles. Regulator is made for operation of single units, or units operating in parallel. Life of contacts is guaranteed for five years. Through proper application of condensers, all radio interference has been eliminated. Regulator is made in sizes for units as small as 5 kw. and as large as 5000 kw.—*Burlington Instrument Corp., Burlington, Iowa.*

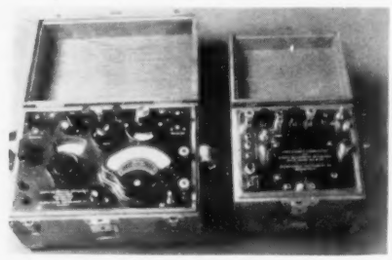


Time and Frequency Standard

A precision time and frequency system has for its visual indicator a clock with an error such that it would take approx. 1½ years before it would differ from celestial time by one minute; and even this minute inaccuracy is not allowed to accumulate and reach an appreciable magnitude. The primary standard consists essentially of a crystal-controlled oscillator, the crystal operating at a frequency of 100 kc. in a temperature-controlled box (± 0.01°F.) feeding into a two-stage multivibrator. The first multivibrator stage reduces the frequency of the original oscillator to 10 kc. and the second delivers an output of 1000 cycles. The 1000-cycle energy is then fed into an amplifier to drive a clock operated by a small synchronous motor. The relatively low crystal frequency of 100 cycles was chosen because of the facility with which it can be either stepped up for high-frequency measurements or stepped down for comparison with Arlington time signals.—*General Electric Co., Schenectady, N. Y.*

Electrical Equipment for Geophysical Prospecting

New Gish-Rooney Resistivity Apparatus, for electrical prospecting, makes it possible to locate deposits of oil and minerals, to find ground water, and—in bridge, dam, foundation, and highway work—to aid in determining depth to bed-rock. Instruments of this general type had been known for some years



but it is claimed that there was no commercial set of instruments ready-to-use in the field. Gish-Rooney Apparatus is said to fill this gap. Improvements in measuring instrument assembly (shown at left) include reduction in size and weight, grouping of controls and dials for easier manipulation, and elimination of the standard cell for all but the most precise work. Commutator unit (at right) is lighter and smaller, and it now employs porcelain cores for the drums, eliminating burning and warping, and minimizing wear.—*Geophysical Instrument Co., 2014 Fifth St., N. E., Washington, D. C.*

Spectroscopy in the Metal Industries

By KEIVIN BURNS

Allegheny Observatory of the University of Pittsburgh

IN several industries it has become necessary to use spectrochemical analysis in order to keep abreast of competitors. It seems timely, therefore, to illustrate the performance of various spectrographs with the hope of assisting industrialists to choose the types which best fit their problems.

Beginning at 2250 A.U., the absorption of air increases rapidly toward shorter wave-lengths. Fig. 1 shows the region of shortest wave-length in which the arc in air can be profitably observed. An important line, the R.U.* (most sensitive line) of zinc, lies near the short end of this region. In spite of the difficulty of photographing 2138 A.U. through air, it is still the best line for detecting small traces of zinc in any metal excepting copper. And even here, the proportion of zinc need not be great (approx. 1 in 100,000) in order to show a line stronger than the rather weak copper line that coincides. In the figure, the line in the copper which coincides with the strong zinc line is actually the result of one part of zinc in a few hundred thousand of copper. Because of the photographic difficulty, the sensitive line of lead at 2170 A.U. is less suitable for analysis than several other lines of lead, some of which are marked in Figs. 1 and 2.

In Figs. 1 and 2 the upper spectrum is that of the copper arc, the middle is brass (88-8-2-2 as a guess) and the bottom spectrum shows the standard spectroscopic graphite arc charged with commercial zinc. The lines which show only in the copper are for the most part lines in the second spectrum of that element. The lines which are strong in copper and brass belong to the first spectrum of copper. Aside from a few zinc lines, the lines which are common to brass and zinc are mainly due to impurities in zinc, though the lead in brass was probably increased intentionally. The silicon and iron lines in the zinc spectrum are impurities in the graphite, but the cadmium comes from the zinc alone. As illustrated in Fig. 2, cadmium is a common impurity in zinc. A small amount of it in brass may not matter, but for galvanizing and for the manufacture of die castings the cadmium content of zinc should be much lower than that of the samples whose spectra are shown. For such purposes the line 2288 A.U., the most sensitive line of cadmium, should be no stronger than the line marked "Sn" in Fig. 2.

Thirty-three years of spectroscopic work, including notable achievements for various industries, have established Dr. Burns as an authority on the possibilities of each type of spectroscope and on the determination of the correct type for each class of applications. To Dr. Burns, therefore, we went for an article desired by many readers: a handy treatment comparing the work of the various types of modern instruments in all spectral regions of industrial interest. (No such discussion had ever been published.) This article not only fills this need, but is noteworthy in other respects: It shows for the first time the benefit of using helium, the separation of manganese and gallium, and the possibility of separating them at 4034 A.U.; and it is unlikely that such good illustrations of other separations (of molybdenum and iron for example) have appeared elsewhere. No article, however, can convey the thrill of seeing an experienced analyst glance at a spectrum photo and say "Too much lead!"—M.F.B.

The region containing the most sensitive tin lines is not shown; the one line which is marked is nearly in coincidence with an air line and so is of little use in analysis. These air lines are numerous in some parts of the spectrum and prevent the observation of faint metallic lines. To lessen this difficulty, Dr. Walters and the writer made some observations of the enclosed arc, the results of which are shown in Fig. 3. The top strip shows the effects of using air as residual gas; the middle strip shows the same metallic spectrum, copper, using balloon gas (97% helium) as the residual gas; the bottom strip shows a longer exposure of the arc in a low pressure (approx. 50 mm. Hg.) of the helium. The air

*Raie Ultime, the term used by deGrammont to denote the last line to disappear with a diminishing amount of the element. It really should be called the Première Raie since it is the first one found.

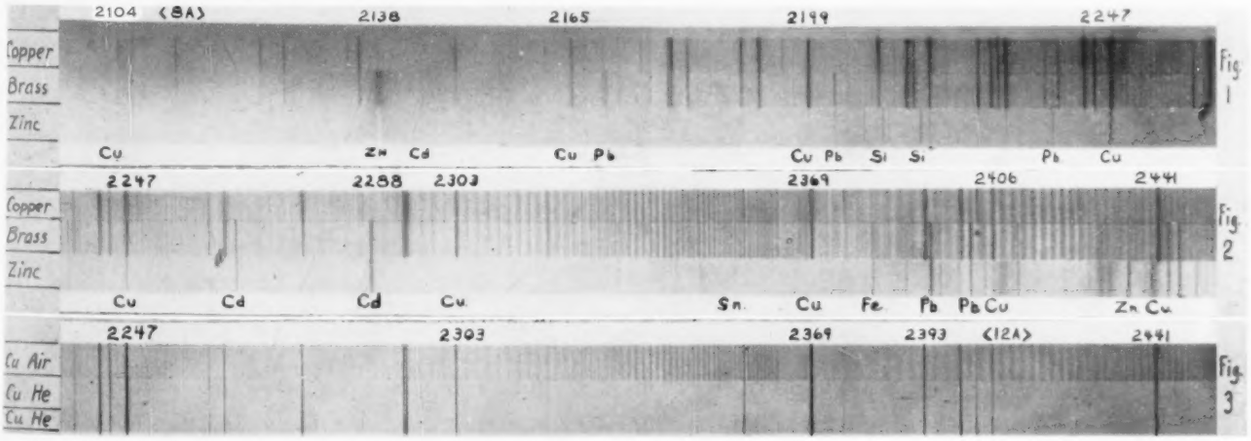


Fig. 1. Copper arc; brass arc; zinc in graphite. Large quartz spectrograph. Fig. 2. Same as Fig. 1.
Fig. 3. Enclosed copper arc, air; enclosed copper arc in helium, atmospheric pressure; enclosed copper arc in helium, low pressure.

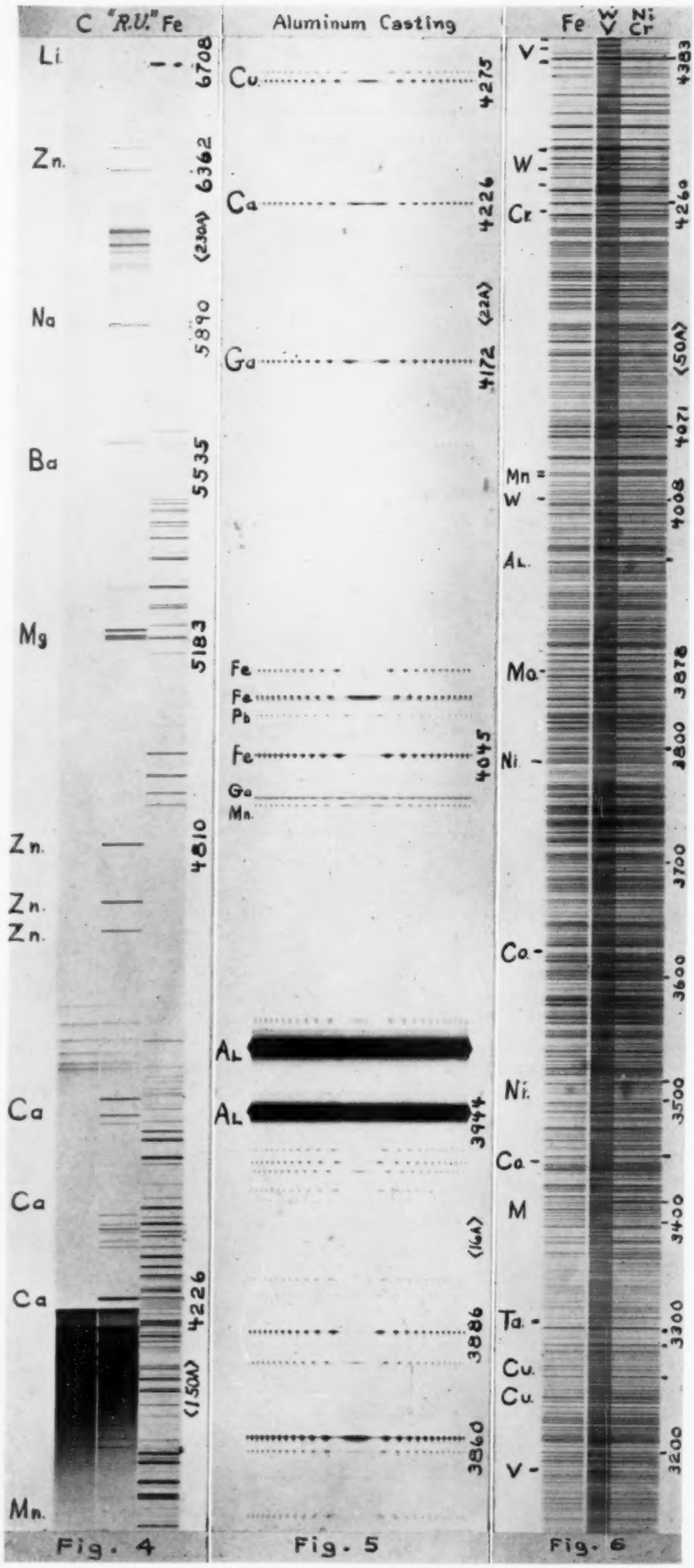


Fig. 4. Graphite; zinc carbonate bearing traces of calcium, barium, magnesium, sodium, and lithium; iron arc with trace of manganese. Large quartz spectrograph. Fig. 5. Aluminum casting, arc in vacuum, showing manganese, gallium, iron, calcium, and copper. Large glass spectrograph with F and P interferometer. Fig. 6. Iron arc; tungsten-vanadium steel; nickel-chromium steel. Grating of moderate dispersion.

bands are seen to be greatly weakened by the use of helium, but they still show faintly because of the slight impurity of the balloon gas. It should be noted that while helium is better for the region shown, the bands of helium are troublesome in some other parts of the spectrum which are free of air bands.

In Fig. 4 the left-hand strip is the spectrum of the graphite electrodes, the middle strip shows this same graphite charged with zinc carbonate to which has been added a trace of a mixture of calcium, magnesium, barium, sodium, and lithium. The right hand strip shows the spectrum of iron with a weak trace of manganese. For all these metals excepting magnesium the lines marked in the figure are the most sensitive in the whole spectrum, and these are the ones most readily found when the element is present as the merest trace. The small dispersion of this figure is sufficient so long as we are dealing with metals having few lines in their spectra. In fact, for some combinations of elements a smaller scale can be used and the whole spectrum from 2100 to 6000 A.U. can be photographed on a 10″ (25-cm.) plate.

Fig. 5 shows the presence of iron, manganese, gallium, lead, calcium, and copper in the aluminum casting; a stronger exposure shows the silicon, and the magnesium lines can be seen on a part of the negative which is not reproduced here. This particular negative was chosen because it has the right exposure to show the separation of the gallium line and the middle line of the manganese triple by means of interference. The stronger pattern is that of the gallium. These two lines are so close (see enlargement in Fig. 5a, page 132) that a powerful grating (200,000) would be required to separate them, yet an interferometer of ordinary commercial grade shows the patterns neatly resolved.

In Fig. 6 the source of the left-hand spectrum is electrolytic iron of fairly high purity; the central spectrum is that of tungsten-vanadium steel; the right-hand spectrum is that of stainless steel, iron-chromium-nickel. The spectrograph has a concave grating ruled 7500 lines to the inch (300 per mm.) and mounted in parallel light as suggested by Fabry and Buisson[1]. This mounting gives stigmatic images near the perpendicular to the grating as pointed out by Wadsworth[2]. The scale of the plate of this instrument is 10 A.U. per mm. and as designed by

[1]Fabry and Buisson. *Journal de Physique*, Series 4, Vol. 9, 1910, page 940.

[2]Wadsworth. *Astrophysical Journal*, Vol. 3, 1896, pages 54-58.

the writer[3] about 2000 A.U. was photographed on a flat plate 8″ (20-cm.) long. Drs. Kiess and Meggers have constructed a 16″ (40-cm.) plate-holder for this instrument; this permits good definition to be obtained over a range of 4000 A.U. by using a curved plate. This has proven to be a useful and convenient instrument for almost every kind of analysis, and such an instrument is highly recommended for general purposes. While the scale is small, the resolving power is good and the observer can separate quite close lines by using a comparator to view and measure the plate.

In the central strip of Fig. 6 a few of the unmarked lines are due to tungsten, but many more belong to vanadium which has a rich spectrum in this region, the most sensitive lines of all being near the long-wave end of the figure. Copper shows only two lines, the most sensitive of the whole spectrum, and these are of about equal strength in all three samples. The position of the most sensitive tantalum line is marked, but a small trace of this element would be difficult to detect in the presence of so much tungsten, some of whose lines coincide with the best tantalum lines. Nickel is strongest in the stainless steel, cobalt shows only in the tungsten vanadium sample. Aluminum shows weakly in the stainless steel. The most sensitive line of tungsten falls at 4008 A.U. Manganese is about equally strong in the two steels, weak in the iron. While the most sensitive lines of chromium 4254 A.U., 4275 A.U. and 4289 A.U., appear to be about equally strong in the steels, this is because they are greatly overexposed in both samples: the weaker lines of chromium show this element to be stronger in the stainless steel sample.

The instrument used to obtain the negatives of Figs. 7 to 10 has a plane grating ruled 15,000 lines per inch (600 per mm.); the lenses are the same ones used in the glass prism spectroscope of Fig. 5. In fact, the prism was merely replaced by the grating. The second order was used for Figs. 7 and 8, the third for Fig. 9, and the first order for Fig. 10. In Fig. 7 the outside strips show the spectrum of a commercial tungsten-vanadium steel similar to the sample of Fig. 6 except that a part of the tungsten has been replaced by molybdenum. The molybdenum lines which are marked are the most sensitive of the whole spectrum. If any great quantity of molybdenum had been present in the steels of Fig. 6 it should have shown in the print, but a trace of this element can be much more easily detected by the use of the instrument of Fig. 7.

Fig. 8 shows a molybdenum steel compared with pure iron. This sample contains no tungsten, vanadium, or cobalt; it has less manganese and a little more nickel than the sample of Fig. 7, and about the same amount of chromium; the molybdenum is somewhat stronger in sample 8. Magnesium and silicon are too low to show in either sample.

Fig. 9 shows a high-dispersion spectrum of pure iron. The strongest lines of the iron spectrum are found in this region which was chosen so as to show the Rowland ghosts at their worst. In using the third or fourth order of a grating (the third

[3]Meggers and Burns, *Bureau of Standards Scientific Paper No. 18*, 1922. Description on pages 191-196. (Dr. Meggers and his associates have further improved the design recently. It is well worth a visit to the Bureau of Standards.—K.B.)

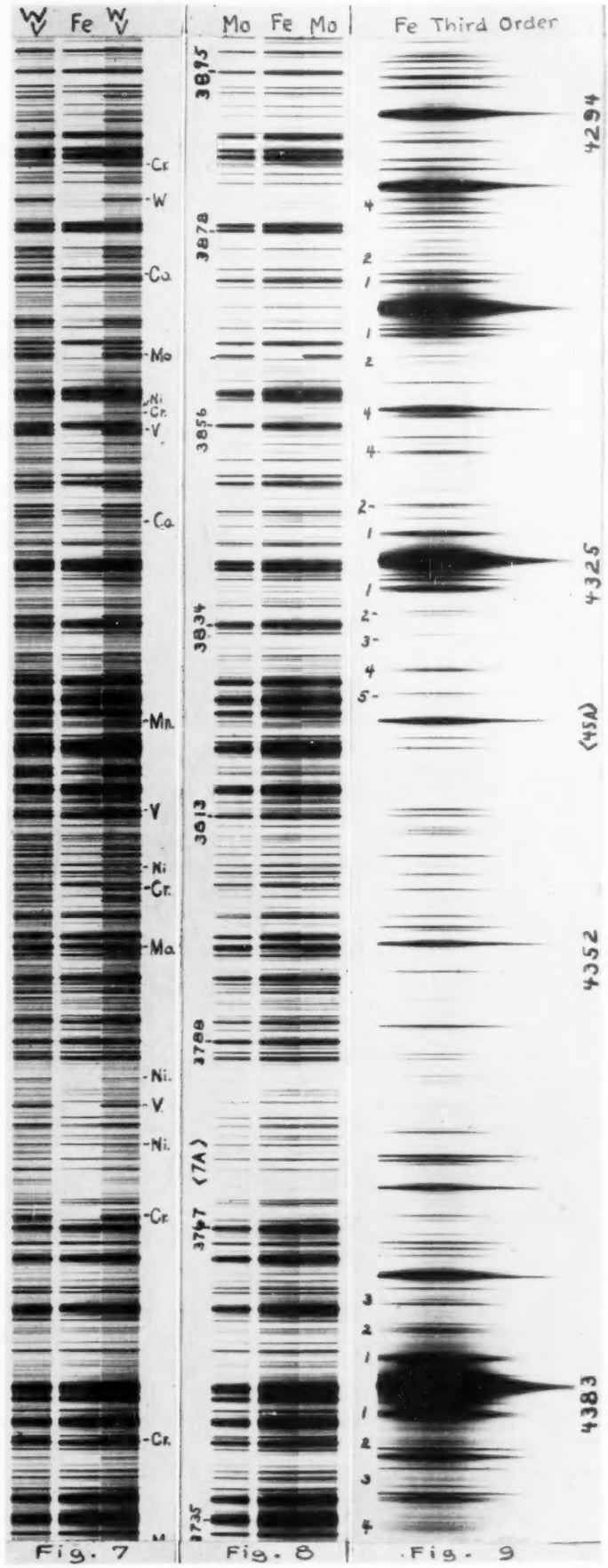


Fig. 7. Tungsten-vanadium steel outside, iron inside. High dispersion grating. Fig. 8. Molybdenum steel outside, iron inside. Fig. 9. Iron arc, exceptionally high dispersion, showing Rowland ghosts of the strong lines.

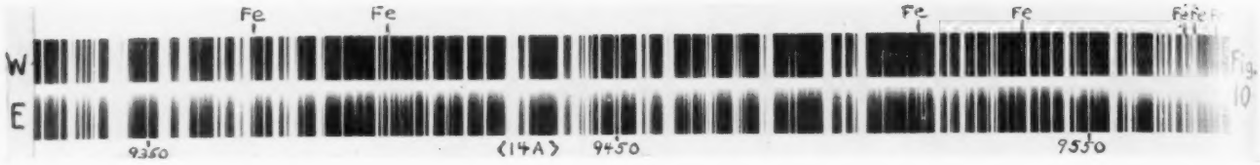


Fig. 10. Solar spectrum in the infrared, showing water vapor absorption lines and a few solar iron lines. Moderate dispersion. The figure being a negative, the absorption lines are white.

order in this case) to obtain high resolving power, one usually finds the ghosts to be relatively stronger than when using the first order. The presence of these false spectra occasionally prevents the observation of an important line of a minor constituent. The grating with which the original of Fig. 9 was made can detect a trace of silicon by means of the line 3905 A.U. in the first-order spectrum, but this line coincides with a ghost if the second order is used. Such coincidences are fortunately rare. At some distance from the strongest lines the spectrum is excellent and the negative from which Fig. 9 was made shows all the lines which ever have been suspected of belonging to iron. Because of the great purity of the sample, its spectrum shows no trace of any other metal. Some of the stronger ghosts are numbered, the smallest number being closest to the parent line. This figure was introduced to suggest the advisability of examining the ghost pattern of a grating before acquiring it for a specific purpose.

Fig. 10 shows the solar spectrum in the infrared. All of the strong lines and nearly all of the weak ones are in register in the two strips. These are absorption lines in the earth's atmosphere. The few lines marked "Fe" are solar lines arising from the absorption of iron vapor in the atmosphere of the sun. The solar lines can be distinguished by the fact that they are shifted to the right in the upper and to the left in the lower strip with respect to the telluric lines. The sun rotates, so the limbs at the equator are approaching or receding. In the figure, the spectra of the receding and approaching limbs are shown in the upper and lower strips respectively. The real solar lines show the Doppler effect. The bands and lines of this figure arise almost entirely from water vapor in our atmosphere. By similar spectra it has been shown that the atmosphere of Venus is rich in carbon dioxide, and that the atmosphere of Jupiter is composed largely of ammonia and methane. On Saturn the ammonia is weaker and the methane stronger than on Jupiter; while on Uranus and Neptune, the atmospheres consist almost entirely of methane.

MISCELLANEOUS RECOMMENDATIONS

For general use in the region of spectrum illustrated in Figs. 1 and 2 the large quartz spectrograph is entirely satisfactory, and this instrument is usually sufficient to handle all analytical problems of the white metal and brass or bronze industries. For the many-lined spectra — iron, tungsten, rare earths, etc.—a grating is more convenient for wave-lengths longer than 2400 A.U. and the advantage of the grating increases with the wave-length. In Fig. 4 is shown the longest region of spectrum for which the quartz spectrograph is recommended for *any* purpose.

On each figure the number of angstroms per centimeter is shown; 8 A.U. at the beginning of Fig. 1, 12 A.U. at the ends of Figs. 1 and 2, 150 A.U. at the beginning of Fig. 4 and nearly 300 A.U. at the lithium line near the end of this figure.

In Fig. 5 the spectrum of an aluminum casting is shown. The spectrograph has a large glass prism and glass lenses of 13-ft. (390-cm.) focal length. The dispersion of this instrument is about six times as great as that of the large quartz at 4200 A.U. This glass spectrograph can be used from 3600 to 9500 A.U., and it is convenient in searching for alkalis, since the most sensitive lines of all the alkalis can be photographed on an 8″ (20-cm.) plate. Of course, to search for the weakest traces of the alkalis in a many-lined spectrum one might prefer a grating. One advantage of any prism instrument is its speed. If only a small sample is available (a few milligrams) it may not be possible to obtain a sufficiently strong spectrum by means of a grating instrument. Another advantage of the prism instrument is the fact that it is commercially available whereas few institutions or instrument firms can rule a good grating—one with a total of at least 45,000 lines, that will give results 80% of theoretical, with ghosts not stronger than 1%.

CONCLUSION

The necessity of using the spectroscope for the analysis of celestial objects has taught the astronomer how to find unsuspected constituents in terrestrial materials, and to analyze these materials quickly and with considerable accuracy. In some cases, notably a small percentage of cadmium in zinc, spectroscopy is not only faster but more certain than wet chemistry. Every company handling a million dollars' worth of metals per year, and every firm spending twenty-five thousand dollars per year on analysis, is advised to consider the possibility that spectroscopy might improve analysis and increase profits. These results have followed the introduction of spectroscopy in several cases known to the writer.

ACKNOWLEDGMENTS

In securing the negatives from which the accompanying illustrations were made, the writer has had the collaboration of Dr. Francis M. Walters, Jr. (now with the Youngstown Sheet & Tube Co.); Miss Mary E. Warga, Physics Department, University of Pittsburgh; Professor Robert W. Boreman, Physics Department, Carnegie Institute of Technology; Father F. J. Sullivan, graduate student, University of Pittsburgh; Mr. Kevin Burns, laboratory assistant, Allegheny Observatory; Mr. Joseph Geffner, graduate student, University of Pittsburgh; and Mr. N. E. Wagman, assistant astronomer, Allegheny Observatory.

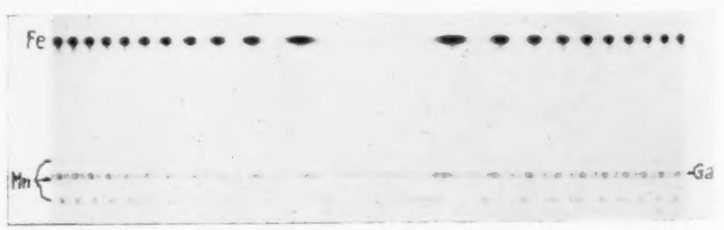


Fig. 5a. Enlargement of portion of Fig. 5.

Wear Resistance in relation to Hardness

Fifth instalment of "Hardness and Hardness Measurements." See page 1, Jan. 1937 issue.

By S. R. WILLIAMS
Professor of Physics, Amherst College

There are at least five, fairly distinct, types of methods which have been employed in the measurement of mechanical hardness:—(a) *abrasion,* (b) *penetration,* (c) *properties of elasticity,* (d) *magnetic* and (e) *electrical methods.* In the fact that some correlation may be found between these diverse methods may be a hope that something like an absolute hardness can eventually be found, or at least arbitrarily defined.

(a) ABRASIVE METHODS

A striking illustration of difference in hardness, as revealed by the abrasive method, is to be found in the marble floor of the Union Railroad Station in Washington, D. C. This floor was laid in squares of a light gray marble, approx. 2 × 2 ft. At each corner of these large gray slabs were set small squares of red marble, about 6″ on a side. See Fig. 30. Countless numbers of feet have shuffled over this floor and have worn off the upper surface of the stone. However, the red blocks now project a small fraction of an inch above the gray, showing that although both kinds of marble have had the same treatment, the red blocks have stood the wear and tear of pedestrian travel better than the gray. The red blocks are harder than the gray. It has been an abrasive process for measuring the relative hardness of the two stones. Future generations will know which kind of stone to select for the longest wearing quality. Just such an illustration furnishes the argument for a better understanding of the property of hardness. Preliminary tests by some practical method before the floor was laid would have shown which of the two would serve the best. It should not have been necessary to wait twenty-five years or so to discover the relative hardness of the two kinds of marble.[1]

[1]D. W. Kessler. Wear Resistance of Natural Stone Flooring. Research Paper No. 612, *Bureau of Standards Journal of Research,* Vol. 11, 1933, pages 635-648.

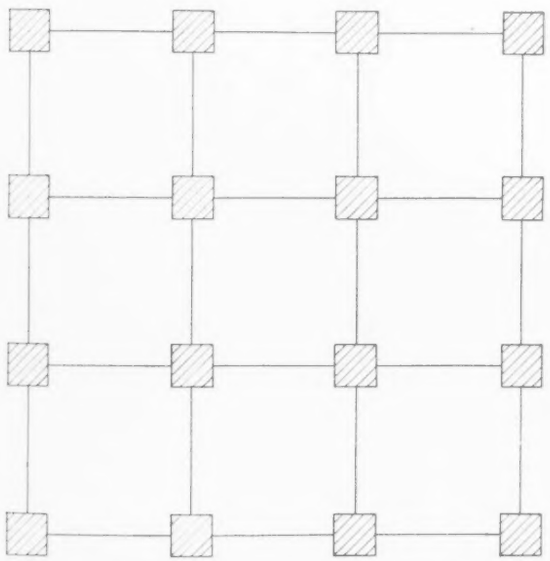


Fig. 30. Design of general waiting room floor, Union Station, Washington, D. C. The large squares are gray marble; the smaller ones red marble.

DIFFERENCE IN HARDNESS BETWEEN SPRING AND SUMMER GROWTH OF WOOD

Another example of difference in hardness, as revealed by a wear test, is found in a piece of wood used in the trough of a sluice-way for gold. An examination of a piece of wood over which water, sand, gravel and dirt have flowed for a considerable length of time shows an intaglio of the soft layers, *i.e.*, the spring wood, amidst the hard or summer wood. See Fig. 31. The same thing occurs in the old wooden spouts formerly used in grain elevators. There can be no doubt that such observations have led others to try to test relative hardness of materials by abrasive methods. Thus Gary[2] studied the resistance to wear by the amount of abrasion caused by a sand blast. Gary made his tests on stones, artificial minerals and timber. Warren[3] also employed a sand blast for studying the hardness of timber. The hardness of woods has considerable theoretical value, because it is neither crystalline nor amorphous in its average structure. One other practical experience lends interest to wear tests. It has been found that coal chutes made of steel do not stand up under the wear given them, as do wooden chutes lined with rubber. One observation should be made on this experience. Abrasion means an actual tearing away of the particles on the surface abraded. In the case of rubber lining for chutes, the resiliency of the rubber allows it to bend down under the point or points pressing against it and thus actual abrasion does not occur as when the sharp points on the chunks of coal strike the surface of a steel chute. The lasting quality of rubber heels and rubber tires are doubtless due to this same factor.

ABRASIVE METHODS USED ON METALS

In studying the conditions under which metals would stand a maximum amount of wear, Dudley[4], from observations extending over a period of 12 years on railroad rails, said that "Metals which will suffer the most distortion without rupture will wear best." If this applies

[2]M. Gary. Versuche mit dem Sandstrahlgebläse. *Mitteilungen aus dem Königlichen Materialprüfungsamt zu Gross-Lichterfelde-West,* Vol. 22, 1904, pages 103-123.

[3]W. H. Warren. Strength, Elasticity, and other Properties of New South Wales Hardwood Timbers. Report Department of Forestry, New South Wales, Sydney, N. S. W., 1911 (100 pages).

[4]C. B. Dudley. The Wear of Metal as Influenced by Its Chemical and Physical Properties. *Transactions American Institute of Mining Engineers,* Vol. 19, 1890-1891, pages 892-909. Discussion, pages 909-911.

Fig. 31. The bottom board to a gold sluicing trough. The abrasive effect of the gravel and water is shown in the wear of the wood.

to all substances, as well as to metals, then Dudley's observation accounts for the increased wear which rubber will stand.

Jannettaz and Goldberg[5, 6] have contributed to this problem of abrasion of metals by studying the comparative losses in the mass of a material by a grinding process. Stoughton and MacGregor[7] used a grinding method but compared these results with an indentation hardness test and found that the comparative results given by the two methods did not correlate in a satisfactory manner.

WEAR OF METALS BY ROLLING ABRASION

Saniter[8] wished to study the wear and tear on the rails of a railroad due to dry rolling abrasion. This is an important problem in the upkeep of a road. Fig. 32 shows the schematic arrangement of Saniter's tests. A specimen of the steel to be tested was fastened by a chuck to the end of a spindle driven by a worm gear. The end of the specimen is shown at *A* in the figure. This could be speeded up to 4000 r.p.m. The steel bar *A* was 5" long and 0.5" in diameter. Over the end of this rod was hung a ball bearing holder so that the inner race course would rotate due to the dry friction between the rod *A* and the inner race course *B*. The outer race course *C* was held in a fixed position by the lever *L*. By means of the latter a load of 205 lbs. could be thrown on the contact surface between *A* and *B*. Rolling abrasion occurred between *A* and *B*. The resistance to wear was taken as being inversely proportional to the reduction in diameter in ten-thousandths of an inch after 200,000 revolutions of the rod *A*.

By means of a similar method, Stanton and Batson[9] made a study of the abrasive hardness of materials and compared them with ball hardness tests. The correlation was not good. A wide departure of the two methods was found for manganese steel. The investigation showed that the abrasive resistance depended much more upon the amount of deformation produced in the material than upon the property of the material in the unstrained condition. The problem, however, was to study the rate of wear due to *rolling friction* under the conditions of heavy loads. This method proved satisfactory in showing rapidly the relative resistance to wear.

Stanton and Batson continued their tests by means of the Saniter method and studied the resistance to abrasion for dry sliding friction. In order to use Saniter's method and at the same time give a relative large amount of sliding motion between the two abrading surfaces, Stanton and Batson connected the inner ball race course to the chuck by means of an Oldham ("flexible") coupling, so that both the inner race course and the specimen completed a revolution in the same time. The line of contact between the two abrading surfaces remained fixed relative to the machine. The results of this test showed that there was very little correlation between wearing tests and Brinell hardness numbers and therefore the Brinell hardness tests were not reliable guides for predicting the relative resistances to wear of a miscellaneous assortment of steels.

[5]P. Jannettaz and M. Goldberg. Dureté des Matières vitreuses et cristallisées, déterminée au moyen de l'usomètre. Association Francaise pour l'Avancement des Sciences, Aug. 9, 1895. *Compte Rendu 24me Session, Part II*, pages 417-425.

[6]L. Jannin. Nouvelle Methode d'essai des Métaux à l'Usure. Machine d'essai à l'Usure. *Revue de Métallurgie, Mémoires*, Vol. 19, 1922, pages 109-116.

[7]B. Stoughton and J. S. Macgregor. Hardness Tests. *Proceedings American Society for Testing Materials*, Vol. 11, 1911, pages 707-708.

[8]E. H. Saniter. Hardness Testing and Resistance to Mechanical Wear. *Proceedings International Association for Testing Materials*, Vol. 2, No. 9, 1912, Paper No. III_1 (7 pages).

E. H. Saniter. A Test for Ascertaining the Relative Wearing Properties of Rail Steel. *Journal Iron and Steel Institute*, Vol. 78, 1908, pages 73-76. Discussion, pages 77-80.

[9](T. E. Stanton and R. G. Batson.) Hardness Tests Research. In Report of Hardness Tests Research Committee. *Proceedings Institution of Mechanical Engineers*, 1916, pages 678-701.

By way of comparison is the work of Nusbaumer[10] with the machine of the Derihon Co. (Belgium). He investigated the abrasion of materials when sliding on another surface in an oil bath. This is a problem of interest to the automobile industry in the behavior of gears in the transmission case and in the differential. This machine was so constructed that the specimen was pressed on to the circumference of a polished wheel turning at a speed of 3200 r.p.m. in an oil bath. The resistance to abrasion was measured by the loss of weight and the reduction in diameter of the specimen in thousandths of a millimeter after 2×10^6 turns of the wheel.

STUDY OF ABRASION IN A SERIES OF CARBON STEELS

Suzuki[11] has made an extensive study of resistance to wear in a series of Swedish carbon steels. The lack of correlation between the abrasive properties of the material tested in the preceding researches and the indentation methods finds this commentary in Suzuki's work. He says, "For the past fifty years, investigations of the abrasion of metals have been made in different ways by specialists of several countries, of which some have

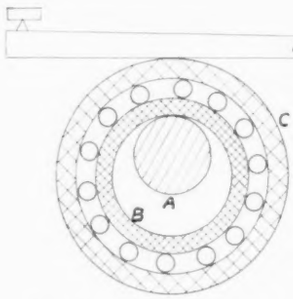


Fig. 32. Saniter's method for studying the dry rolling abrasion of railroad rails.

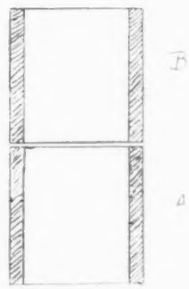


Fig. 33. Suzuki used his material in the form of hollow cylinders. The wear was measured on the ends abutting each other.

shown very important and valuable results. But in such investigations, the quantitative results have not thrown light upon the true nature of abrasional resistance owing to difficulties caused by several factors affecting the experiments and also to inadequate apparatus and method of measurement.

"Most of the results so far obtained conflict and cannot be quantitatively compared with one another, which is due to an important factor having been ignored. They have neglected the fact that the experiment should be made by keeping the coefficient of friction of two substances equal, which is one of the most influential factors in abrasion experiments, because the amount of abrasion varies not only with the property of substance, but with the fineness of the contact surface, even with the same substance. In other words, abrasion produced between two substances varies widely with the coefficient of friction between the surfaces of contact."

In the study which follows these introductory remarks, Suzuki pays especial attention to keeping the coefficient of friction constant as far as possible. It is

[10]E. Nusbaumer. Note sur les Essais d'Usure pour Métaux. Presented at Fifth Congress of International Association for Testing Materials, Copenhagen, 1909, but not printed in the 1909 volume. Lengthy illustrated abstract in *Revue de Métallurgie*, Vol. 7 *Extraits*, 1910, pages 7-11. Brief abstract in *Stahl und Eisen*, Vol. 29, 1909, pages 1661-1662. For English mention of this machine see Portevin & Nusbaumer, Note on the Wear of Bronzes, Sixth Congress of International Association for Testing Materials, 1912 Paper No. III_4 (13 pages).

[11]M. Suzuki. An Investigation of Abrasion in Carbon Steels. *Journal Society Mechanical Engineers* (Japan), Vol. 30, 1927, pages 559-626. Also printed in English in *Science Reports of Tohoku Imperial University, Series I*, Vol. 17, 1928, pages 573-638.

difficult factor in the technique of the study of relative hardness by abrasive methods. Suzuki's study was an extensive one on six hypo-eutectoid carbon steels of different carbon contents and of different structures. At the beginning the author defines two kinds of abrasion: (1) "The amount of abrasion per unit area and unit work of a substance, A or B, with respect to a standard substance, C, is defined 'Standard Abrasion'." (2) "The amount of abrasion per unit area and unit work of B with respect to A, or vice versa, is defined 'Relative Abrasion'." Few measurements of relative abrasion had been made prior to this work, but such measurements are essential in solving abrasion problems.

The importance of such studies may be estimated when one considers the industrial and economical losses caused by abrasion. The abrasion which goes on between the rails and the rims and flanges of the wheels rolling over the rails is but one example of economical loss by such means. Suzuki's method carried him into a study of the relative abrasions between variously heat treated structures such as obtain in the annealed, sorbitic, troostic and martensitic structures. His results showed conclusively that the greater the hardness number, the less was the abrasion effect. These studies showed further that if the standard abrasion was once determined, then relative abrasions could also be found by calculation.

The method used by Suzuki consisted of a rotator, Fig. 33, carrying a hollow cylindrical test piece B, whose inner and outer diameters were 1.60 and 1.96 cm. respectively, and whose length was 4 to 5 cm. Butted end to end in a vertical position with B was another test piece A of the same dimensions. B was rotated by a motor and *A* was held on a shaft mounted on ball bearings. A pulley was attached to the same shaft as *A*, around which was wound a cord leading to a spiral spring. The spiral spring carried a pen which moved over a sheet of paper on a rotating drum. By the movement of the pen, the frictional force between the two abrading surfaces could be watched and kept constant—an important feature of the method. Different loads could be applied to the surfaces of contact by placing weights on the upper spindle *C*. This allowed the relative abrasive powers of two samples to be studied under different speeds and different loads while the coefficient of friction was maintained as nearly constant as possible. The author claims for his outfit the following advantages:—

1. The relative abrasion between two substances can be measured.
2. A comparatively large abrasion is produced in a few minutes.
3. The cooling is rapidly produced on the contact surface where the measurement can be carried out.
4. The condition of the contact surface is held always constant because its form is concentrically circular.
5. So, no error is caused by the edge of the test piece during the rotation.
6. The experiment can be done with the contact surface easily immersed in any liquid or powder, that is, at any constant coefficient of friction, because the axis of the test piece is vertical.

The area of the two surfaces in contact was two square centimeters. The load carried on the upper rotating (active) test piece was 18 kg cm^{-2}. The coefficient of friction was kept as near 0.65 as possible. In the final results it was shown that in the case of rolled and annealed structures, the relative abrasion of the active test piece increased linearly with the carbon content (that is, with hardness). The average ratio of abrasion between the two speeds was 1.70. The difference between steels of different hardness and difference structures was also studied. "When the test piece of a higher hardness rotates at a higher speed, the amount of wear in each piece is smaller than in the reverse combination."

The effect of powder upon abrasion was most marked. In fact, the results of this study makes it appear as though abrasion depended, for the most part, upon the powder produced between the two disks. The abrasion was almost 100 times greater when the powder remained than when it was wiped off.

Suzuki's extensive investigations are well worth study.

To be continued

Army's Gage Laboratory at N. Y. U.

By CARLOS De ZAFRA

Assistant Professor of Engineering, New York University
Major, Ord. Res., Chief Gage Laboratory, New York Ordnance District

IN order to make possible the quantity production of interchangeable parts, manufacturers are compelled to adopt many close tolerances for their machine shop operations. In the early days of the steam engine a cylinder bored a quarter-inch out of round was accepted as a good job. Today tolerances are held to the third and even the fourth decimal place. To assure the maintenance of production standards to within 0.001" requires checking or gaging devices accurate to the fifth and even the sixth decimal place. Few industries can afford to equip themselves with such expensive precision measurement and gage checking instruments because of their great cost in relation to their relatively infrequent use. In industries where gages are used, a gage department, provided with only a few elementary precision check gages will usually be found. Extremely precise measurements and certain check gages would have to be returned to the gage manufacturer or sent to the National Bureau of Standards in Washington, D. C., for test and certification as to accuracy.

It will therefore be of interest to industry to know that the Ordnance Department of the United States Army has established a complete precision measurement and gage laboratory in the College of Engineering, New York University, for use by the Army, the College and industry generally. The writer, as Major in the Ordnance Reserve Corps and Chief of the Gage Division of the New York Ordnance District, is in charge of the laboratory, the only one of its kind in the New York Ordnance District or outside of Frankford or Watervliet Arsenals on the Atlantic Coast. [See front cover illustration.]

Calibrated by the National Bureau of Standards, instruments in the new laboratory are capable of linear and angular measurements accurately to the fifth and sixth decimal places.

The equipment includes several sets of Johansson and of Hoke precision gage blocks accurate to the millionth of an inch; a measuring machine of capacity from 0 to 4 feet and accuracy of one one-hundred-thousandth of an inch; a screw thread comparator; a comparator for checking relative sizes of small parts and capable of being read to the three-millionths of an inch; a helium monochromatic light-wave interference instrument to determine the flatness of precision gage blocks; a set of a new type of micrometer plug gages; a super micrometer; toolmaker's microscope; machine for determining the lead on exterior and interior screw threads; 3-wire system of measurement for Acme and National 60° screw threads, and in addition a complete assortment of accessories such as surface plates, inside and outside micrometers of various capacities, dial indicators graduated to ten-thousandths of an inch, box parallels, vernier depth and height gages; in short, apparatus and equipment for practically any linear and angular precision measurement.

Cathode-ray Oscillograph Applications

Twenty-third part of "The Cathode-ray Oscillograph and Its Applications" being published serially in *Instruments*. This series began in July 1935 issue.

By RALPH R. BATCHER

Radio engineer; cathode-ray and electronic application specialist, Hollis, L. I., N. Y.

IN THE BIOLOGICAL SCIENCES[15-23]

It is manifestly impossible to review all the practical applications of such a versatile tool as the cathode-ray oscillograph that have to do with research in biological fields. Since some of the methods may be of value in industrial fields, however, a few will be mentioned.

In the fields of psychological and medical analysis the problem comes up of delineating nerve impulses and muscular reactions under various conditions or stimuli, as exemplified in electrocardiography.

One of the early electrical demonstrations was that of Galvani who showed that some sort of relation existed between muscular activity and electrical currents. These experiments were made using the muscles of frogs. The most important developments toward the utilization of the currents generated by the body organs were made by Einthoven, using one of the string galvanometers bearing his name. These researches were directed toward the recording of the cyclic potential waves generated by the heart as an improved method of diagnosis. The exact nature of these potentials is not fully known fut the technique that Einthoven developed experimentally has become almost universally used in making electrocardiograms.

In order to explain the action, an analogy might serve to illustrate the methods used. Assume that the intensity of the beam from a lighthouse is arranged to be varied in a certain manner which is repeated each revolution. Assume also that there are three receiving observers positioned in three different directions, that it is not possible to measure the light intensity directly at any one of these positions, and that it is easy to measure the relative difference in the light intensities received at any two of the three positions. This difference varies continually over the cycle of revolution—at one instant it will be stronger at point A than B, and later this condition will be reversed, and so on for B-C and for C-A.

Although subject to some qualifications, the view may be taken that the movements of the various compartments in the heart each generate and project potential waves in certain directions. This assumption will permit the analysis of the recording methods. Electrical contacts are made on the surface of the skin at three points, say on each arm and the left leg. Oscillograms are successively made showing the potential difference between each of the receiving positions. It has been found that each oscillogram is distinctive and follows a standard form if the heart is normal. Likewise variations have been systematically analyzed permitting rules to be formulated showing the type of cardiac disorder. Fig. 5a shows a typical oscillogram for the left arm-right arm condition.

From a scientific standpoint it may seem that this method is indirect and that other methods, as for example one delineating a polar diagram, would give superior results. Equipment complications result however with any other method than the one used and any change in this recording technique would require considerable research in order to formulate rules whereby the diagrams could be analyzed.

With the ordinary galvanometric oscillograph it has been customary to make a continuous photographic record of each set of conditions, so that it is necessary to expose and develop many feet of film during a single test. This has been due to the fact that all transient effects due to muscular exertion must be quieted if a true record is to be obtained. Since the phenomena to be studied occur at a slow rate (about once per second) the eye cannot retain a picture of a complete cycle when the mirror reflection is viewed directly. With the cathode-ray types of oscillograph this technique may be altered since a delay screen can be used wherein a complete cycle can be retained by phosphorescent screen action. Subsequent cycles are all superposed so that momentary or gradual changes can be noted visually, before any photographic record is taken.

The apparatus required consists of a special low-frequency amplifier and an oscillograph with a synchronized linear time base capable of following the fluctuations at the pulse rate. The amplifier must have sufficient gain to amplify an input potential of one millivolt so as to give the required deflection. The deflection is generally calibrated in millivolts, and on the film record should be one cm. per millivolt. In the usual case

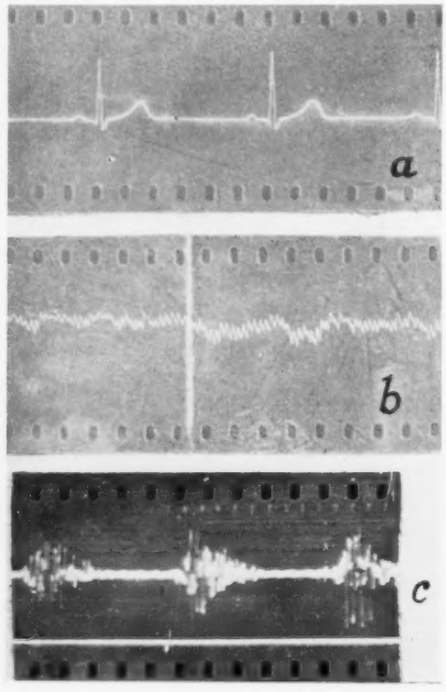


Fig. 5

[15]Wiggers. Principles & Practice of Electrocardiography. C. V. Mosby & Co., St. Louis, Mo.

[16]Wiggers. Physiology in Health and Disease. Lea & Febiger, Philadelphia, Pa.

[17]Horton. D. C. Amplifiers. *Journal Franklin Institute*, Vol. 216, 1933, pages 749-762.

[18]Forbes-Davis & Emerson. Study of Action Currents. *Review of Scientific Instruments*, Vol. 2, 1931, pages 1-15.

[19]Brookes-Smith. Cathode Ray Electrocardiograph. *Electrical Communication*, 1935, pages 235-239.

[20]Gasser & Erlanger. Studies in Nerve Reactions. *American Journal of Physiology*, Vol. 62, 1922, pages 496-502.

[21]Watanabe & Sangama. Cathode-ray Oscillograms of Action Potential of Nerve. *Scientific Papers of Institute of Physical & Chemical Research, Tokio*, Vol. 21, 1933, pages 139-148.

[22]Der Kathodenstrahl Oszillograph in Biologie und Medizin. By Dr. Ing. Wolfgang Holzer. Verlag Mandrich, Vienna.

[23]Galli & Pastori. Contributi del Laboratorio di Psicologia. Publications Catholic University of the Sacred Heart. Milan, 1935, Vol. 7: Oscillographic studies of speech and language.

input potentials are of the order of one to two millivolts. It must have a flat frequency characteristic over the range of from 0.5 to 1000 cycles per second, the latter limit being set by the extremely rapid surge occurring at one point on the oscillogram. It is desirable that visual monitoring be possible before and during any exposure interval. The oscillograms must be timed accurately in terms of tenths of a second or smaller intervals to enable accurate interpretation of the pictures.

Since all three electrodes are placed in position before the test a switching arrangement is usually provided so as to connect in the desired pair of leads. No line frequency hum can be permitted. Figs. 6 and 7* show stationary and portable forms of an electroencephalograph which is primarily arranged to record "action currents" associated with mental processes, but is also useful as an electrocardiograph and for other physiological investigations. Its amplifier output operates a cathode-ray tube with which are associated a sweep circuit of conventional design and a camera for still pictures or continuous records. This amplifier drives likewise a power amplifier that supplies a loud-speaker and an ink-writing oscillograph. The cathode-ray tube is used for recording all types of "action currents" and the ink writing oscillograph is limited to the registration of the electroencephalogram or brain wave.

The term "action currents" refers in general to the currents generated by the activation of living tissues, nerves, muscles, etc. Figs. 5b and 5c are oscillograms of action currents, the latter depicting the action currents in a human muscle, taken with the Electromyograph* shown in Fig. 8, designed primarily for the study and diagnosis of muscular action in paralytic cases, etc. This instrument is for recording the action currents in nerves and muscles only. It operates directly from 60-cycle power lines. Here, again, the cathode-ray tube has a sweep circuit and the camera is adapted for still and continuous pictures. The camera records simultaneously a series of flashes from a timing lamp to indicate the speed of the film, and the motions of a luminous pointer pneumatically operated by the muscle from which the action currents are led. This instrument finds application in the study of certain forms of paralysis and in research on the cause of stammering. It may be used to map out the pathways of nerves, to measure the speed of the conduction of the nervous impulse, and to determine the efficacy of nerve sutures. The electrodes used with this instrument are small hypodermic needles which have minute glass-insulated silver wires running down the channel. These are connected to the amplifier with shielded cords and are used like miniature telephone plugs which tap the electrical activity of a small volume of tissue and are shielded from extraneous interference.

Fig. 9 shows a five-bay electrophysiological equipment, used for investigations of extraordinary character, including the delineation (on the cathode-ray tube screen) of the electrical effects taking place in the ears of animals when various sounds are produced nearby.

To be continued

*Figs. 6, 7, 8 and 9 show apparatus designed by Lovett Garceau for the Electromedical Laboratory, Inc., Holliston, Mass.

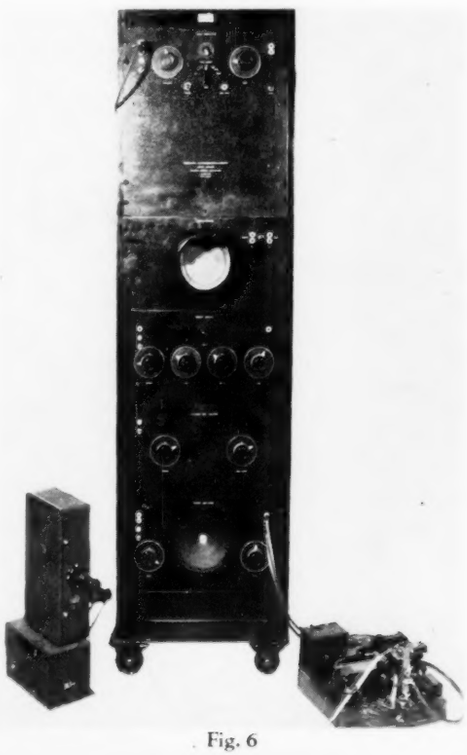


Fig. 6

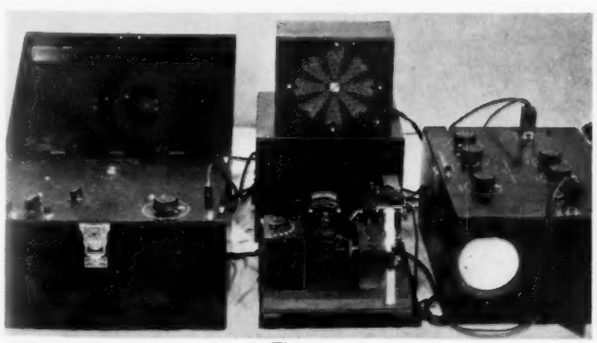


Fig. 7

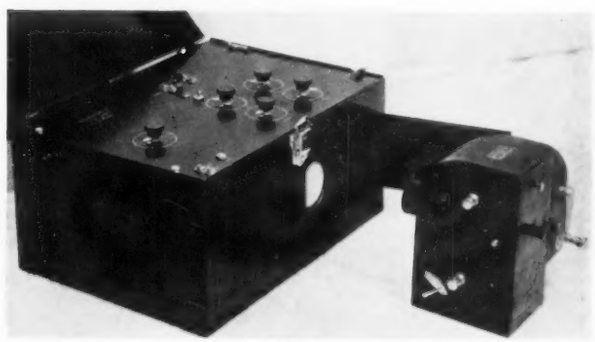


Fig. 8

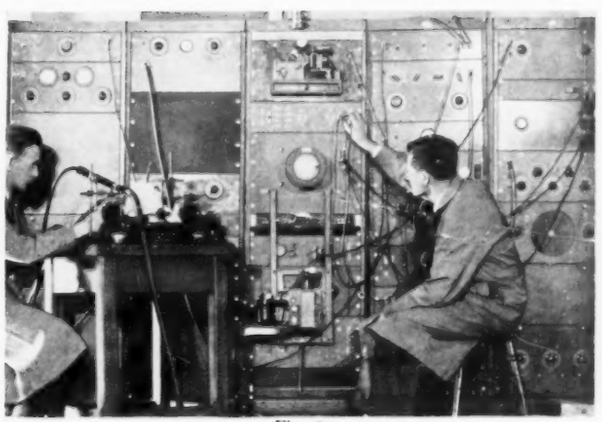


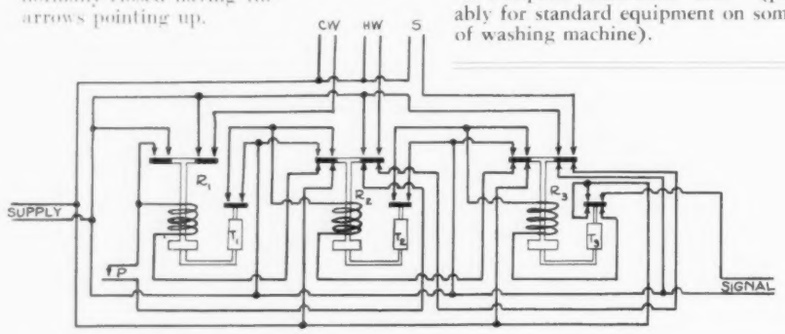
Fig. 9

INSTRUMENTATION FORUM

PROBLEMS — SOLUTIONS — DISCUSSIONS

$5 PRIZE SOLUTION
By NATHAN P. BRESLAUER

Apparatus: Three relays R_1, R_2 and R_3, and three mechanical timers T_1, T_2 and T_3, operated by the plungers of the corresponding relays. Relay R_1 has two sets of normally-open contacts; R_2 and R_3 have two normally-open and two normally-closed each. Timers T_1 and T_2 have one set of normally-open contacts each and timer T_3 has one normally-open and one normally-closed. These are shown on the drawing, normally-open contacts having the arrows pointing down and normally-closed having the arrows pointing up.

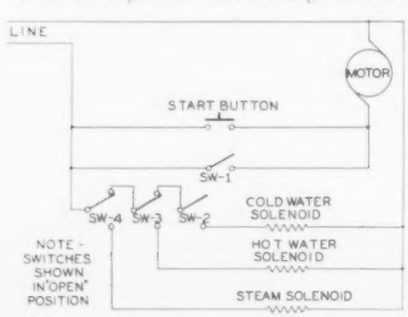


Operation: When button P is pressed, relay R_1 closes, opening valve CW and operating timer T_1 set for thirty seconds. After thirty seconds, T_1 closes, closing R_2, which opens valve HW and releases R_1, closing valve CW. At the same time, the plunger of R_2 operates timer T_2 set for twenty seconds. After twenty seconds, T_2 closes, closing relay R_3 which opens valve S and releases relay R_2, closing valve HW. At the same time, the plunger of relay R_3 operates timer T_3, set for thirty seconds. After thirty seconds, timer T_3 closes, releasing relay R_3 and operating a signal to indicate completion of cycle.

The left-hand normally-open contacts on each relay hold that relay closed until opened by the next succeeding. The right-hand normally-closed contacts prevent recycling until the previous cycle is completed.

$5 PRIZE SOLUTION
By E. R. WYATT

Herewith is the schematic wiring diagram of an instrument to take care of this problem. The motor in the schematic diagram is the motor which drives the cam of a Bristol's sequencing timer, by means of which circuits are successively made through the wires feeding the three solenoid valves. This sequencing timer is constructed so that the mechanism which "makes" the circuit through any branch, "breaks" (in the same motion) the circuit in the preceding branch, thus giving clean-cut action. Another feature of the timer is a ready means for adjusting the duration of any dwell. A momentary push button is used for starting: the timer will automatically stop at the completion of a cycle in a reset position ready for a new cycle without manual reset.



MARCH PROBLEM (No. 5)

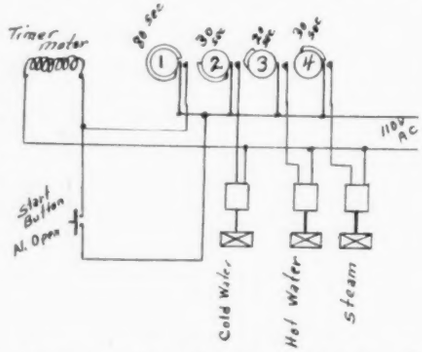
Automatic Time Cycle

Three ½" solenoid valves, all normally closed: cold water (cushioned); hot water (cushioned); steam (100-lb. max.). *Cycle:* Push button start, CW opens; 30-sec. dwell; CW closes and HW opens; 20-sec. dwell; HW closes and S opens; 30-sec. dwell; S closes and cycle stops.

Inquirer sends us blueprint of a 3-disk panel, considers its cost prohibitive. suggests "an arrangement with a single 30-sec. timer on each operation," prefers "a complete assembled unit" (presumably for standard equipment on some sort of washing machine).

$5 PRIZE SOLUTION
By STANLEY T. WEPSIC

Have solenoid valves operated by an 80-second "cycle stop" cam timer with the individual cams set for the desired operation of each valve. Cam No. 1 to be a total time cam and cams 2, 3 and 4



to operate the cold water, hot water, and steam valves. Start operation by closing start button until contacts of cam No. 1 close. Cycle stops after 80 seconds by the opening of the contacts on cam No. 1. Timers of this type are available with adjustable cycles and automatic reset.

$5 PRIZE SOLUTIONS
By JOHN W. FULTON

(1) Assuming that the quantity of machines to be equipped with time cycle control is sufficient to make use of semi-standard relays, a simple two-unit solution is shown in Fig. 1. A sequence relay with 9 stages carrying 4 sets of contacts, 3 single-pole, single-throw and one double-throw, arranged in the program shown, controls the valves. The operating coil of the sequence relay receives one pulse each 10 seconds from the timing relay after receiving its first pulse from

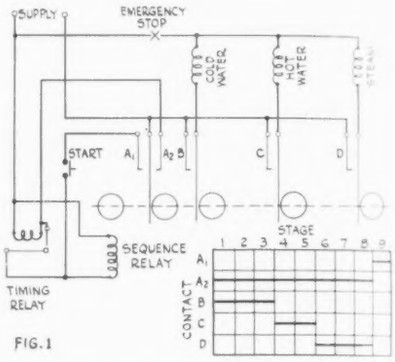


FIG. 1

the start push-button. Contact A_1 is opened in the first stage, preventing interference with the program from accidental operation of the start push-button after the cycle has started. Contact A_2 closing in the first stage maintains current in the operating coil of the timing relay throughout the cycle. A switch to close all the valves in an emergency may be installed in the common lead to the valve coils as shown.

If a particular relay manufacturer would prefer to do so, a 9-position "sunflower" switch with a single-pole double-throw "off-base" contact could be used in place of the ratchet-and-cam type of sequence relay shown in the illustration.

(2) An alternate solution, carrying out the suggestion of the inquirer to use a separate timer for each valve, is shown in Fig. 2. If the delay between the completion of one cycle and the beginning of another, required by the reset time of thermal time delay relays, and their inaccuracy, are not objectionable, they would offer a somewhat cheaper solution.

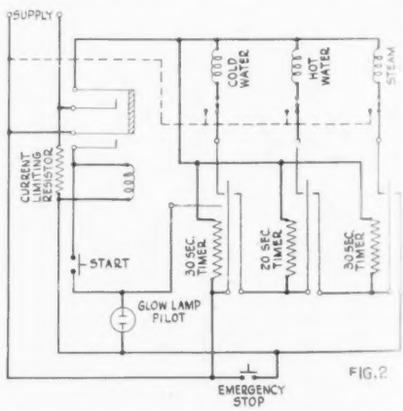


FIG. 2

These timing relays must be arranged to break one circuit before making the other with as little delay as possible. The first relay is provided with an extra contact arranged to close only after the relay has cooled to reset position. The cycle is initiated through the start push-button which closes the electrically interlocked

relay, applying current to the coil of the hot timing relay and the cold water valve. 30 seconds later the cold water valve is closed, and the hot water valve opened by the contacts of the first timing relay. The coil of the second timing relay also receives current simultaneously with the hot water valve. In this manner the cycle progresses and is completed by the closure of the normally-open contact of the third timing relay, shorting out the coil of the interlocked relay, thereby removing current from the coils of all the timing relays.

A neon glow lamp type of pilot (drawing a smaller amount of current than the pick-up current of the relay) may be connected as shown to indicate the reset condition of the timing relays. A normally-open push-button connected across the relay coil may be used as an emergency stop switch. Single-pole double-throw switches connected as shown by the dotted lines may be used to operate the valves manually without control by the timing system. One objection to this system not found in the previous method is the loss of control in the event of a power interruption during the cycle.

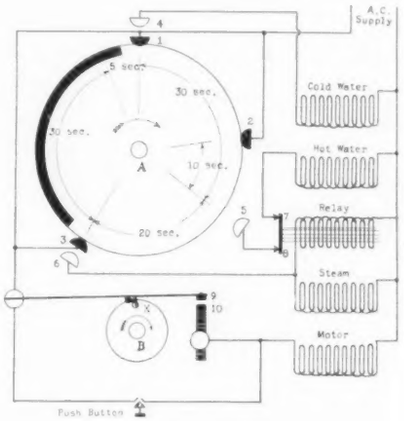
If the program as outlined could be changed to one of three equal intervals of time, the first method described would become more simple, in that a four-stage sequence relay and a timing relay giving one pulse for each of the uniform intervals could be used.

Any one of a number of manufacturers of relays, etc., should be able to supply either system mounted on a single panel pre-wired.

85 PRIZE SOLUTION

By CHARLES A. ELLIS

This timer consists of a single contact-operating disk (made of insulating material) driven by a synchronous motor at a speed of one revolution in 85 seconds. Carried upon this disk is a contact shoe of conducting material having an angular spread equivalent to thirty seconds of time. Arranged in pairs around the circumference are three pairs of brushes which operate to contact the valve-operating solenoids. Brushes No. 1 and No. 4 are at a position that may be designated as zero time and in line. It is seen that as the shoe passes in a clockwise direction brushes No. 1 and No. 4 are shorted to hold the cold-water solenoid valve open for 30 seconds. Brush No. 2 is 20 seconds from zero and No. 5 is 30 seconds from zero. At the instant that the shoe leaves No. 1 it contacts No. 5 and through No. 2 it operates the hot-water solenoid valve. This circuit is held closed for 20 seconds and but for No. 3 would be opened as the shoe cleared No. 2. At the instant that the shoe leaves No. 2 it reaches No. 3 and No. 6 in line at 50 seconds from zero and so operates the steam solenoid valve and the relay in parallel with it. Operation of the relay opens the normally-closed contacts No. 7



and No. 8 and releases the hot-water solenoid valve. The steam solenoid valve is in operation for 30 seconds while the shoe is passing contacts No. 3 and No. 6 and is released as the shoe clears. It will be noticed that there is still 5 seconds left before the revolution of the disk is complete. At some time during this period pin "X" on disk "B" operates to open contacts No. 9 and No. 10 and so stop the driving motor. Disks "A" and "B" are shown separately in the drawing for simplicity and should be on the same shaft. In the actual timer the pin "X" would be placed in disk "A." In order to start the cycle the push-button is held long enough for the motor to drive pin "X" to release contact No. 9, thereafter the motor circuit is maintained through Nos. 9 and 10 until cycle is complete.

Problem No. 7 **Subject Index 2.05**

DETERMINING PUMP EFFICIENCY

From a large phosphate company: "We desire meters integrating (in ft.-lb.-hrs.) the discharge of sand pumps in mining pits. Max. vacuum on suction side is under 28″; max. head on discharge side is under 200 ft. Percent of solids varies so much that load fluctuates from 1/4 load to heavy overload (quite unlike test-block where a pump handling clear water runs at constant load and speed). We easily meter the electrical energy consumption, but desire to meter simultaneously the work actually performed, in order to obtain significant data."

Five dollars will be paid for every solution (or critical discussion clearly pointing the way to a solution) which is accepted for publication. Address Instrumentation Forum, 1121 Wolfendale St., Pittsburgh, Pa. Type double-space, on one side of paper. Draw diagram in black ink on separate sheet. Mail before June 15. Solutions and discussions accepted will appear in July 1937 issue.

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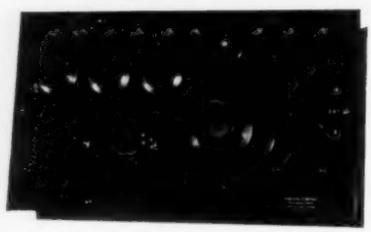

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INSTRUMENTS' BOOK SHELF

The Microscope (16th Edition). By SIMON HENRY GAGE. Comstock Publishing Company, Inc., Ithaca, N. Y., 1936. Cloth, 6" × 9⅛", viii + 617 pages. Price $4.00.

Professor Gage should be highly complimented on preparing a book on the microscope that can live through sixteen editions. Of late years his new editions have added chapters on special applications. The fourteenth added a chapter on Dark Field Illumination and the fifteenth a chapter on Ultra-violet Microscopy. The present sixteenth edition contains these same chapters and in addition a chapter on Micro-incinerations and the optical appliances for their examination.

"The Microscope" is written primarily for the student as a text book. It is the kind of book which is easy to read and grasp the meaning without having the assistance of an instructor. The book is profusely illustrated where illustrations are necessary to show the right and wrong way of carrying out experiments. The author encourages such experiments so that the reader who wants to learn to use a microscope can actually practice the technique described before he tries to apply this technique to his own particular problems. Each chapter is concluded with a list of recommended collateral reading.

The fundamental principles of the biological microscope, both monocular and binocular, and the polarizing microscopes are carefully explained. Paralleling these explanations are suggestions of how to use and when to use the various forms of illumination in studying structures.

All of the useful microscope accessories are described and examples of their use given in detail. Such accessories are the Spectroscopic Eyepiece, Camera Lucidas, Micrometers, Dark Field Condensers, Comparison Eyepieces, Demonstration Eyepieces, and Photomicrographic Apparatus.

Carefully written instructions for fixing and preserving tissues and entire organisms, as well as imbedding, sectioning, staining and mounting constitute one of the important chapters in this book.

The author describes in the chapter on Micro-Incinerations the technique used by Dr. Gordon H. Scott of Washington University, St. Louis. Micro-incineration is the burning away of all organic matter leaving fixed on the slide only the non-volatile inorganic matter. This method of specimen preparation requires no staining. However, it is recommended that alternate sections be mounted and stained so that both a stained section and a micro-incineration of the same material may be examined and compared. The methods of dark field illumination, polarized light, and fluorescence are applicable to the examination of micro- incinerations.

An interesting chronological story of the development of lenses in the microscope is the concluding chapter of this valuable book.

—L. V. FOSTER, *Scientific Bureau, Bausch & Lomb Optical Co., Rochester, N. Y.* (7.7)-B-

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Practical Testing in Metal Industry (Hilfsbuch für die praktische Werkstoffabnahme in der Metallindustrie). E. DAMEROW & A. HERR. Verlag von Julius Springer, Berlin, 1936. Paper, 6½ × 9⅞ inches, 80 pages. Price 9.60 RM.

This book was intended as a manual for the testing laboratory and inspection department. Nineteen pages briefly cover the handling of test specimens in the tensile test, the hardness tests of Brinell, Rockwell, Vickers, Shore and scratch method, as well as the notch toughness test and the testing of welds. The remainder of the book has 42 pages for calculating (in metric units) stress, elongation, reduction of area, hardness, relation of the various hardness values to each other, a few physical constants and English-metric conversion factors. The book will be of assistance to test engineers and inspectors. The reviewer did not check the values contained in the various tables, but in glancing over them noticed on page 79 an obvious error in reporting a long ton as 3240 lbs. —RICHARD RIMBACH. (3)-B-

Reports on Progress in Physics, Vol. II. ALLAN FERGUSON, General Editor. The Physical Society, London, 1936. Cloth, 7 × 10 inches, 371 pages, price 21s.

This book gives an excellent comprehensive survey, by a number of authors, of research in physics for the year 1934. The chapter headings are:

General Physics (classical)
The quantum theory
Atomic physics
Geophysical prospecting
Radio exploration of upper-atmospheric ionization
Sound
Heat
Electrical and magnetic measurements
The charge of the electron
Electron tubes
X rays
Spectroscopy
Optics

How rapid and extensive progress is, though hard to realize, is evidenced somewhat by the need for great brevity found in these reports in order to compress them within a reasonable number of pages and still to cover all works that have made reasonable contributions to physics. At the end of each chapter excellent bibliographies are to be found. As is to be expected, a large majority of the references relate to 1934 publications. In certain chapters, however, a large number relate to relevant earlier publication, while in certain other chapters many 1935 references are mentioned.

In certain fields the progress has been so rapid that many advances have been reported through the journals during the period when the material of this book was being compiled. However, to one who wishes a rapid summary of a field in which the reader is not altogether familiar, this book will serve a useful purpose. It will not long be considered as live material on the library shelf. This would seem to be particularly true of the section relating to atomic physics.

To one of the reviewers the subject, heat, seems admirably covered. To the other it seems that the final topics of the book such as optics and its allied subjects are of little value and serve chiefly as space fillers. It would have been better had this section been omitted. Undoubtedly, others will view these parts differently.

—A. G. WORTHING, *Head of Physics Dep't, and* W. N. ST. PETER, *Professor of Physics, University of Pittsburgh.* (12.1)-B-

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Brown Flow Meter Engineering Handbook. Compiled and edited by LOUIS GISS and J. O. FELDMARK. The Brown Instrument Co., Philadelphia, 1936. Fabrikoid, 8 × 10½ inches, 162 pages, price $2.00.

Appearance is almost always the last thing mentioned in a book review. In this case, however, the reviewer cannot resist the impulse to start with an enthusiastic comment on the sumptuous printing and binding: never in technical literature has he seen so lavish a use of large type—even in the cleverly-spaced tables, in the index and in the footnotes; of white space, and of large-scale illustrations—all on high-grade coated paper, and durably bound in rich Spanish-grain imitation leather.

Solicitude for the reader not only governed those who looked after typography and production, but it evidently governed the authors in the preparation of their book—particularly in their thoughtful division of a relatively lengthy text into convenient chapters (termed "Parts"). These are as follows:

(1) General Flow Meter Engineering; (2) Orifice Design; (3) Steam Flow Measurement; (4) Water Flow Measurement; (5) Liquid Flow Measurement; (6) Air and Gas Flow Measurement; (7) General Tables and Data; (8) Summaries — symbols, equations, curves, etc.

Part 1 should really be entitled "construction of head meters" since it deals only with that class (almost entirely with the orifice type) and since it is descriptive of design and construction details. Part 2, on the other hand, has too limited a title, for it deals not so much with the design of orifices (which is a matter for manufacturers) as with

Continued on page 142

Roller-Smith "Hipot" Potential Indicator

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Typical Installation at Hudson Switching Station.

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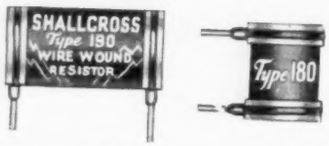

Bulletin 121-H gives the electrical and mechanical specifications of the standard types of Shallcross accurate wire wound resistors.

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the correct choice and proper installation of orifices. Parts 3 to 6 are correctly described by their titles: they are the real meat of this book, containing a wealth of data of direct usefulness to users, in the forms of discussions, of tables, and of large charts and diagrams—many specially prepared.

Not satisfied with this creditable achievement, the authors have compiled Part 7 which takes forty pages and presents almost every conceivable bit of additional information which the user of Brown Mechanical or electrical flowmeters might want to look up. And into the bargain is thrown a final summary of symbols and equations! The book is certainly worth two dollars of any power plant engineer's money.

—M. F. Behar. (2.05)-B-

The Renaissance of Physics. By Karl K. Darrow. The MacMillan Co., New York, 1936. Cloth, 6 × 8¾ inches, 308 pages. Price $3.00.

The publisher's announcement began as follows: "Atoms so minute that it would take one hundred millions of them lying side by side to extend one linear inch. . . . Corpuscles of light, invisible to the eye, yet able to pierce through plate- armor, provoke explosions of atoms, and attack the center of life itself. . . . Such are some of the incredible, fantastic things described by Dr. Karl K. Darrow in his fascinating account of the miracles. . . ."

We were reading it at breakfast, and when the good wife asked what made us stab the grapefruit so savagely, we thundered that we'd like to stab the writer of this Hollywoodish advertisement; that it would be incredible and fantastic if the advertised book were to deal with atoms **not** of that order of magnitude and were to state that **no** photons can pass through armor plate, disrupt nuclei or kill organisms. Knowing, however, Dr. Darrow's outstanding ability to report interestingly the significant recent progress in physics, we felt sure that *Instruments'* readers should have the book brought to their attention. We ordered it. On pages 5 and 6 we came across the following:

"In these pages there will be discourse about atoms which are so small that it takes one hundred million of them lying side by side to extend one linear inch. . . . I shall write a great deal about particles moving so swiftly that they could go around the globe at its equator in less than a second... corpuscles of light unable to cause vision in the eye, but amply able to pierce through armor plate. . . . Many of these things are going to sound wildly fantastic and inconceivable, should there be any reader who never has met them; and that indeed is how they ought to sound."

Evidently, then, the author's aim was to "sell" physics to laymen. This purpose would perhaps have been achieved better if he had not strained his hyperboles, for his unaffected *current* [illegible] style can charm most readers. The spell is broken again when he pauses to ask "Isn't this fascinating?" Fortunately, there aren't more than a dozen such asides—and many readers will enjoy them. Even those who don't like magniloquence will enjoy the book as a whole. Dr. Darrow refers impersonally (on page 106) to "a scholarship rare among physicists," but *he* himself possesses it: Aphorisms, classical parallels, metaphors, similes, clever new definitions and gems of English abound throughout this book. Here are a few stylistic gems:

"The atom changed from fancy into fact when, repudiating its own name, it proved itself divisible!"

"Astronomy has sprinkled the earth with giant telescopes for exploring the infinities of space, and its students congregate around them; now physics is building colossal high-voltage engines for invading the recesses of the atoms, and the laboratories where they stand are becoming the centers of research communities as notable as those of the observatories."

"Some of the rarest isotopes probably remain to be discovered . . . but the emotion of the first analysis is one which we shall never taste again."

"An institute of physical research is as proud of a notable grating by Rowland or Wood or Gale, as a picture gallery of an authentic Titian or Velasquez."

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"May we say that 'vacuum' shall stand for any density of gas, however high or low, provided only that what is left of the gas in the tube is not interfering at all with the phenomena which we happen to be observing?"

"Notice that I have already begun to speak of 'rays'; this is a term applied to anything which moves in straight lines or in smooth curves, and of which the effects can be seen (or otherwise perceived) while the thing itself cannot."

"If there were no positive [nuclear] charges, the electrons would have to disperse to the ends of space, they could not possibly organize their constellations nor go into their incessant interwoven dance; and if the positive charges which exist were borne by particles no more massive than the elec-

Continued on page 144

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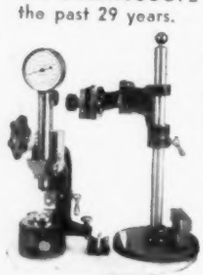

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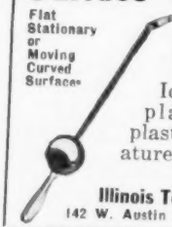

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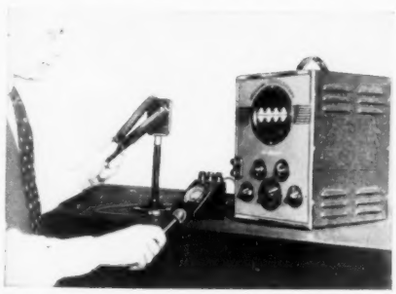
Tuning by the Isochrometer Method with the

NEOBEAM OSCILLOSCOPE



The illustration shows a standard and a non-standard tuning fork held before a microphone and the NEOBEAM OSCILLOSCOPE indicating the difference in pitch. The pattern of the non-standard fork drifts, indicating the adjustment necessary for synchronization of the two periods of vibration. *Any tone source or instrument can be similarly compared and calibrated.* Beats of 10 seconds duration easily observed.

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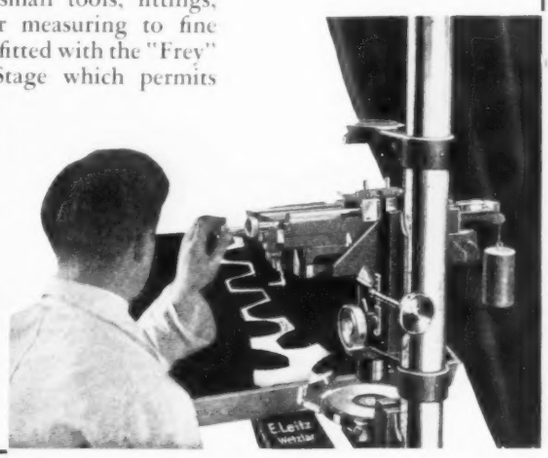

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trons, these particles themselves would join too ardently in the dance."

The catchy title does not accurately describe the contents of this book: It is an almost "non-mathematical" but not quite "popular" survey of those phases of physics which in recent years have captured the attention of the literate public. It is an amplification of a course of lectures. These must have been prepared in some haste, for there still remain errors and disputable statements. On page 64 Darrow refers to an "excess of negative charge on one of the plates—the cathode C—and an equal *excess* on the other—the anode A." (Italics ours.) On page 41 he writes "cathode" instead of "anode." In tracing the history of cathode rays he credits almost everybody except Goldstein who named them, who discovered their important properties and who made possible J. J. Thomson's discovery of the electron (see Thomson's autobiography). On page 33 Darrow refers to "electrode" as "Faraday's pretty name" and on page 37 he writes "cathode and anode as Faraday named them." Faraday didn't coin these terms.

Not a passage can be called slipshod: Darrow being an artist; but in his haste he let stand some passages which must be called awkward. For example, his superb "rings of current" exposition on page 95 is followed by a lengthy superfluous explanation of clockwise and counterwise. On pages 169-170 he injects a boresome explanation of frequency into a chapter which is over the heads of those who don't know what frequency means.

Another consequence of the book's origin in a course of lectures is that the word "very" is used almost as many times as there are pages—unnecessarily in probably 99 cases out of 100. Such vague expressions as "a simply fantastic number" tend to exasperate the serious reader. Here is another example: "In *heated* sodium vapor there are *some* free negative electrons and *some* free positive particles, but also there is a *great number* of neutral particles . . . If, on the other hand, we heat the gas to *an exceedingly high temperature, a considerable fraction* of the atoms will suffer the loss of one electron (or maybe even of two or more) and there will be *a lot of* fresh positive ions and *a lot of* fresh loose electrons . . ." (Italics ours.)

Defective editing, too, mars the book: "different than" (page 66); a reference on page 248 to a "shaded band" in the figure printed on page 249—which has no shaded area; and the lack of uniformity in the mathematical typography.

In spite of its flowery style, the book contains (in the latter chapters) much information which a majority of *Instruments* readers will find decidedly useful. The range of subjects covered lies almost entirely in the realm of atomic physics—the first few chapters giving a review of electrostatics, magnetostatics, electromagnetism and radiation, in order to introduce the meaty and genuinely fascinating last four chapters. This reviewer has read the entire book through, and has re-read several times a number of pages in the last four chapters, with profit and with ever-increasing delight.

—M. F. Behar (12.1)-B-

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